

Preprints

Historical Painting Techniques, Materials, and Studio Practice

University of Leiden, the Netherlands

26–29 June 1995

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Historical Painting Techniques,
Materials, and Studio Practice



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COVER ILLUSTRATION

Gherardo Cibo, "Colchico," folio 17r of *Herbarium*, ca. 1570. Courtesy of the British Library.

FRONTISPIECE

Detail from Jan Baptiste Collaert, *Color Olivi*, 1566–1628. After Johannes Stradanus. Courtesy of the Rijksmuseum-Stichting, Amsterdam.

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Foreword

One of the first events organized by the Getty Conservation Institute as it began its activities about ten years ago was a symposium on paintings conservation. We felt at that time that our particular approach, based on multiple disciplines looking at a single problem, could contribute significantly to the field of conservation. Over the course of the past years we have continued to develop in that direction and with that belief, so it is particularly appropriate to see these important preprints come to light for the University of Leiden's symposium.

The history of painting techniques is by nature a multidisciplinary area of study, combining research in science, conservation, and art history as well as specific expertise in paintings. Members of each one of these professions bring to the area their own detailed knowledge in artists' materials, techniques, or methods, whether it be information specific to pigments, binding media, signature style, or archival research.

The field of history of painting techniques has been evolving very rapidly in recent years and opening enormous opportunities for further research and connoisseurship, as this important group of papers demonstrates. Not only scientific methods of examination but also bibliographical and archival research are making significant contributions.

The authors of these preprints bring a wide array of expert knowledge as well as many fresh points of view that are certain to provoke serious questions and debate. The editors—Arie Wallert, Erma Hermens, and Marja Peek—have assembled this volume with a most insightful approach and focus. So it is with a great deal of satisfaction and pleasure that we present these papers for the study, and enjoyment, of a fascinating and challenging field.

Miguel Angel Corzo, Director
The Getty Conservation Institute

Preface

This volume of preprints, prepared for an international symposium on Historical Painting Techniques, Materials, and Studio Practice at the University of Leiden, the Netherlands, 26–29 June 1995, contains the results of work on historical painting techniques from all parts of the world. The suggestion to organize such a meeting was raised during the symposium on the Technology of Art Works from the Central European Region organized by the Archives of Art Technology in Prague in 1993. The Prague symposium emphasized Czech painters and their techniques. To broaden the scope of attention, Erma Hermens of the Art History Institute of the University of Leiden and Marja Peek of the Art Historical Department of the Central Research Laboratory for Objects of Art and Science in Amsterdam took on the task of organizing a second meeting in Leiden.

The purpose of the symposium and this publication is to promote a greater understanding of the changing boundaries and interaction between art historians, conservators, and conservation scientists working in the fields of historical painting techniques—including wall paintings and polychrome sculpture—painting materials, and studio practice.

In recent years, there has been an increasing interest in historical painting techniques. The study of the painting techniques and materials used throughout history and in various cultures is by nature an interdisciplinary exercise. In the past such studies were sometimes conducted with little interaction between art historians, conservators, materials scientists, and historians of science, because each discipline tends to present the results of its studies to different forums. This volume aims to present different approaches to the study of historical painting techniques in the hope that it will encourage cooperation among these various disciplines.

Information about painting techniques can be gained in a variety of ways, including the chemical or physical analyses of the materials found in the paintings. Analyses of a large number of paintings attributed to certain regions, schools, workshops, or individual masters can contribute to a history of painting techniques. Analytical results can also help art historians assess attributions and can support or reject their hypotheses. The analysts, however, need the art historians to inform them about the stylistic idiosyncrasies and significance of those schools, workshops, or masters.

It is often rewarding to see what artists have said about their own work and to study their written sources on painting techniques. This kind of information has come down to us in diaries, such as Neri di Bicci's *Ricordanze*; in painting handbooks such as Cennini's *Libro dell'Arte*, in anonymous recipe books; and even in model books, such as Stephan Schriber's *Musterbuch*. These recipe books tell scientists what substances to look for in analysis. Both scientific and art historical information help us understand the significance of sometimes rather obscure recipes and tell us whether the methods and materials described are common or exceptional for the particular period. Today it is not unusual to find information from historical sources incorporated in the examination of individual paintings.

The discussions in this volume present historical painting techniques from a variety of professional perspectives. With its wide range of topics and approaches to the study of historical painting techniques, this publication is presented in the hope that it will provide an impetus for further studies that involve material science, art history, conservation, archaeometry, and the history of science. We also hope it will be one in a series of such interdisciplinary and collaborative volumes.

In addition to thanking all the colleagues at our institutions who helped us with advice and expertise, we also would like to acknowledge the invaluable work and support of several individuals in particular. Miguel Angel Corzo, director of the Getty Conservation Institute, immediately supported the idea to publish the presentations of the symposium and generously provided his time and support in the production of the present volume. Agnes Gräfin Ballestrem, director of the Central Research Laboratory for Objects of Art and Science in Amsterdam, and A. W. A. Boschloo of the Art History Institute of the University of Leiden supported the entire project from its initial stages and advised us during the editorial process. Corinne Lightweaver and Jo Hill, independent editorial consultants, carried out invaluable work on the manuscripts, assisted by Joy Hartnett. In the preparation of these preprints for publication, we also wish to thank Dinah Berland, publications coordinator, the Getty Conservation Institute.

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Plate 1a, left. Bartolomeo Vivarini, active 1450–1491, Saint Peter, 1490. Tempera on panel. From Polyptych with Saint James the Greater, The Virgin and Child and Other Saints. The J. Paul Getty Museum, Malibu (71.PB.30).

Plate 1b, above. Detail from Vivarini's Saint Peter, showing clearly visible, individual brush strokes.



Plate 2a, above right. Attributed to Raphael, 1483–1520, Portrait of a Young Man, 1505. Oil on panel. The J. Paul Getty Museum, Malibu (78.PB.364).

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Plate 6, above. Pigment containers: paint bladder to collapsible tube. Fitzwilliam Museum, University of Cambridge.



Plate 7a, above. Valerio Mariana da Pesaro, *Battle of San Fabiano*, 1618–1620. Photograph by E. Buzzegoli, Laboratorio di Restauro. Courtesy of the Uffizi Gallery, Florence.



Plate 7b, right. Detail from *Battle of San Fabiano*, 1618–1620, showing the landscape in the background built up with several transparent washes of color. Photograph by E. Buzzegoli, Laboratorio di Restauro. Courtesy of the Uffizi Gallery, Florence.

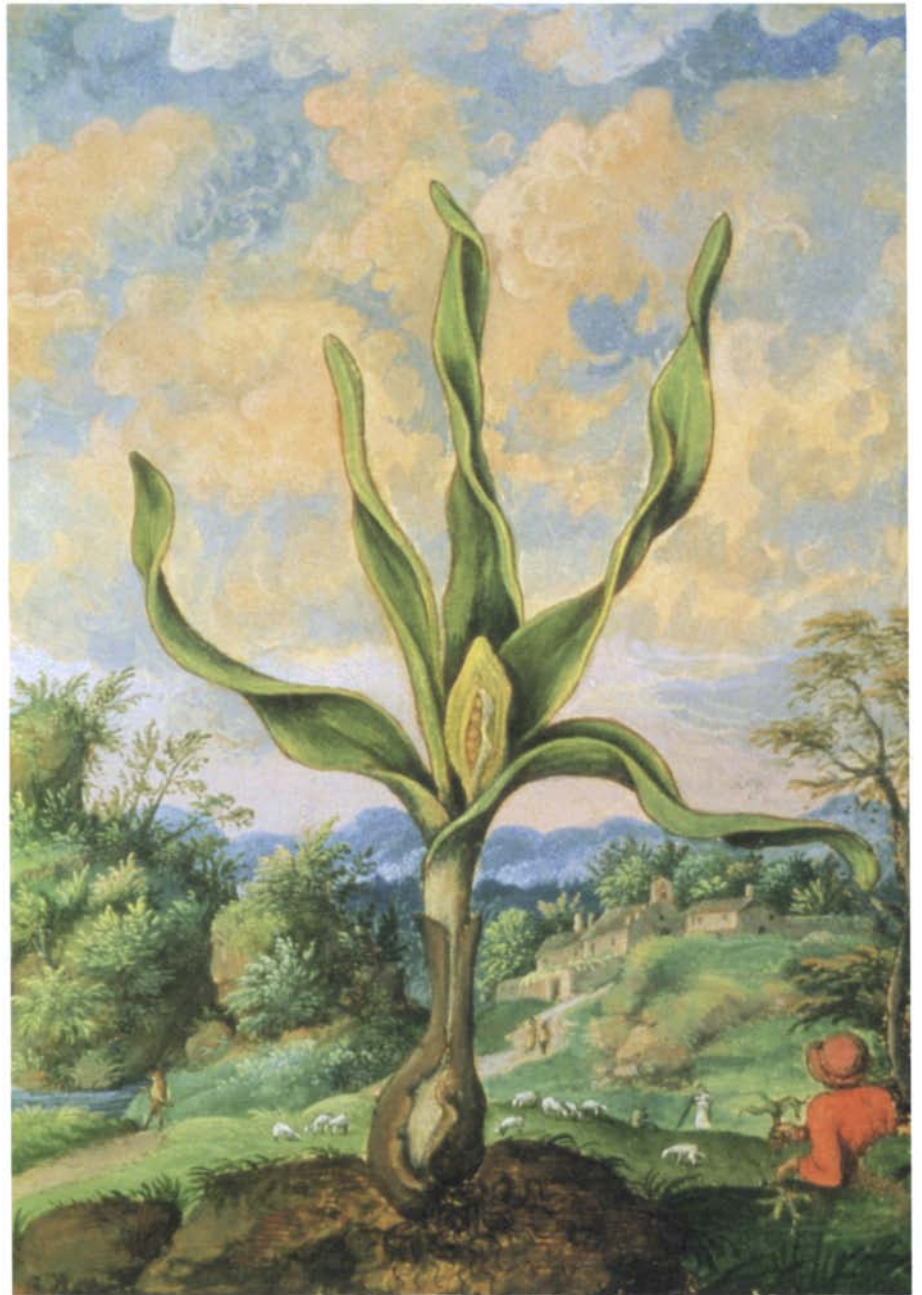


Plate 8. Gherardo Cibo, "Coldico," from *Herbarium* (MS ADD 22333), folio 17r, ca. 1570. Courtesy of the British Library.



Plate 9. Marco Palmezzano, *Mystic Marriage of Saint Catherine*, signed and dated 1537. Photograph by Christopher Hurst. Private collection.



Plate 10. Detail from Marco Palmezzano's Mystic Marriage of Saint Catherine, showing green glaze dabbed on St. Catherine's garment. Area shown measures approx. 3 × 4 cm. Photograph by Christopher Hurst. Private collection.

Plate 11. Cross section from Palmezzano's Mystic Marriage of Saint Catherine, showing of the green baldachin of the throne in normal light (×200). Photograph by Christopher Hurst. Private collection.

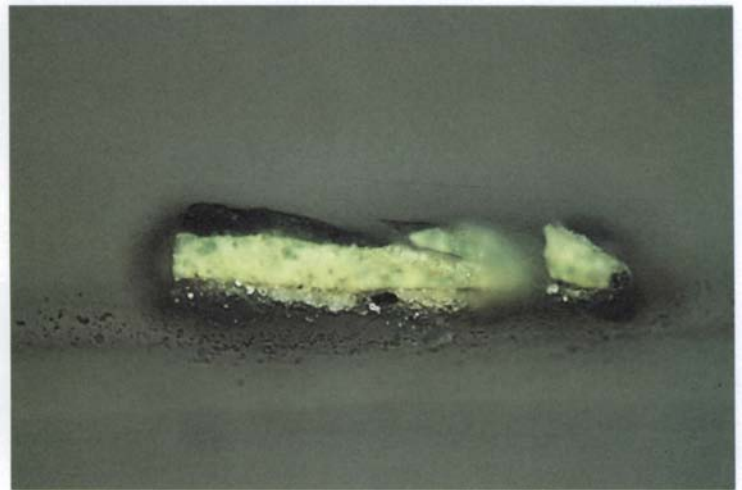


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Plate 14, below. Krishna and Girls, 1730-1735, Basohli miniature. Smalt with high arsenic content in the sky and Krishna's skin. Photograph by Paul Robins (Photo Studio), courtesy of the Victoria & Albert Museum (I.M.87-1930).

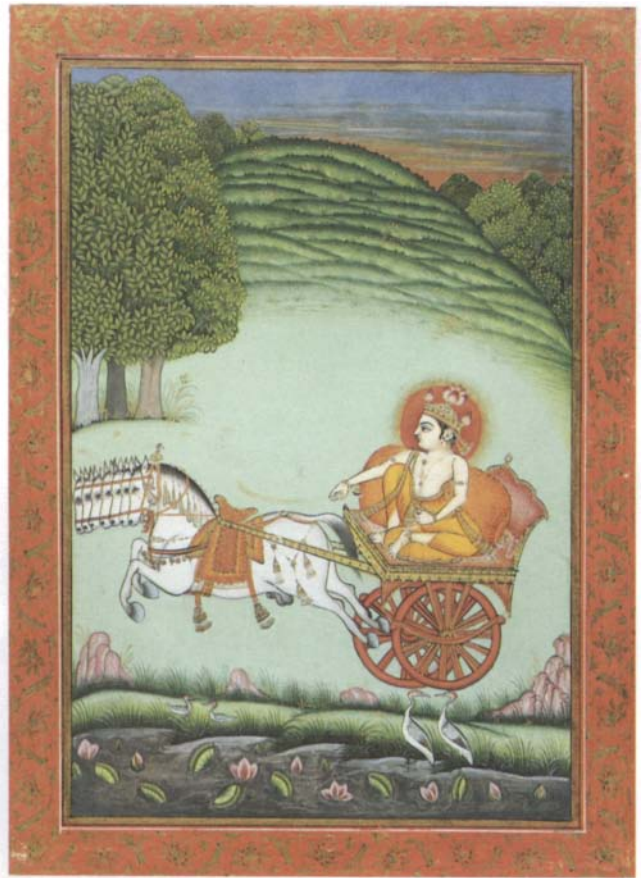


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Plate 16. The Fifth King of Shambhala. Glue bound paint on cotton, 80.9 × 43.3 cm. Denman Waldo Ross Collection, Museum of Fine Arts, Boston (06.324).





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Plate 20. Cross section of Sample 3, taken from the olive-green background near the leg of Nicodemus in the Deposition on the east wall. The charcoal black inclusions within the plaster substrate are clearly visible; over this, a layer of natural ultramarine is present. The present green appearance is due to the layer of vivianite on the surface of the sample. Originally a blue color, some of the particles have altered to a yellow color, and in the center of some of the yellow particles, the original blue color is just discernible. Photograph courtesy of the Conservation of Wall Painting Department, Courtauld Institute of Art, London.

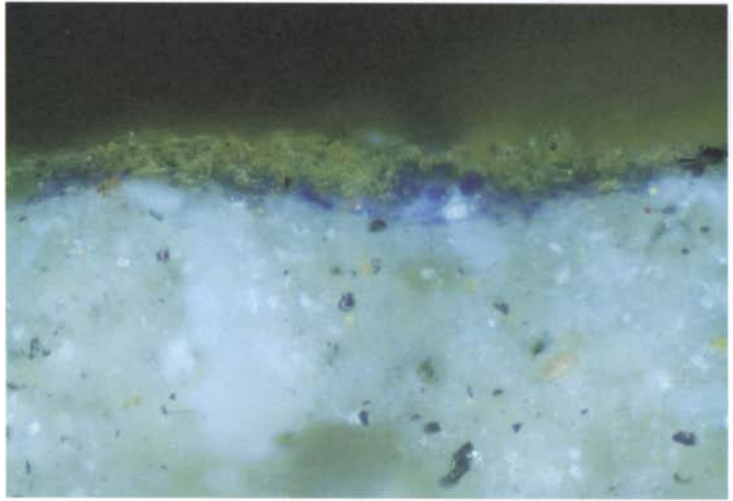


Plate 21. Photomicrograph of sample from central porch tympanum, Salisbury. Cross section shows complex structure, representing several repaintings and including vermilion, red and white lead, iron-oxide red and yellow, black, blue, and possibly gold.

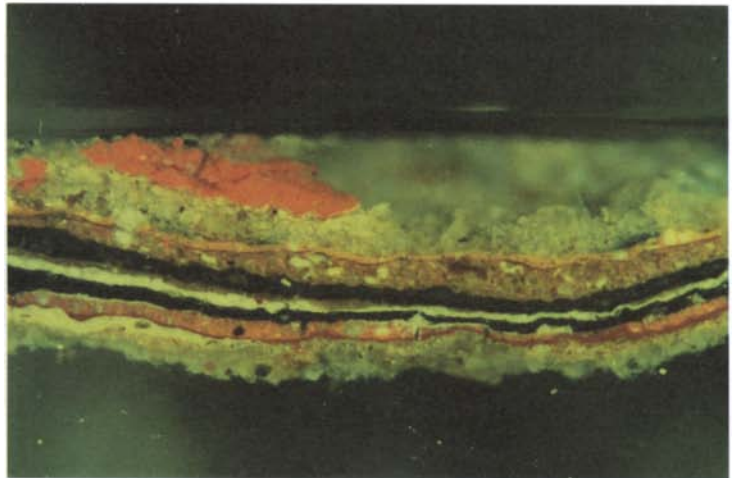


Plate 22. Photomicrograph of sample from Exeter west front. Cross section shows pink primer, white lead, and verdigris top layer.

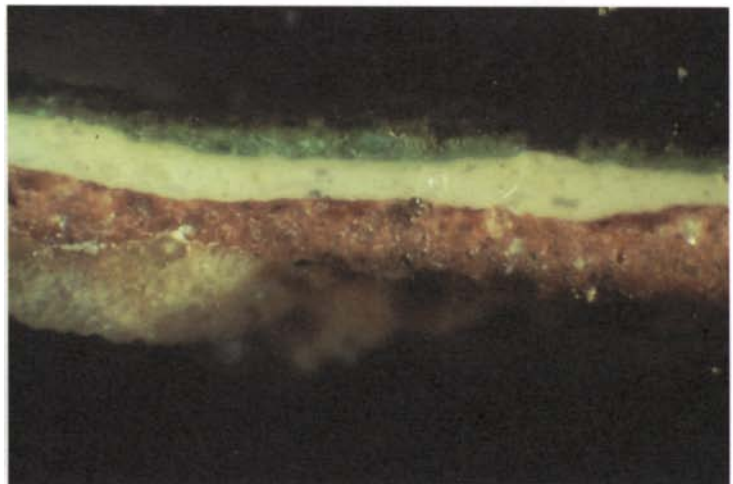




Plate 23, top. Andrea Mantegna, *The Adoration of the Magi*. Distemper on fine linen, 54.6 × 69.2 cm. The J. Paul Getty Museum, Malibu (85.PA.417).

Plate 24, left. Detail from *The Adoration of the Magi*, upper left-hand corner, showing feathered-out colors on the edges of the painting, originally under the frame. The J. Paul Getty Museum, Malibu (85.PA.417).

Plate 25, above. Detail from *The Adoration of the Magi*, lower edge, showing feathered-out colors on the edges of the painting, as in Plate 24.



Plate 26, top. Titian, Venus and Adonis. 160 × 196.5 cm. The J. Paul Getty Museum, Malibu (92.PA.42).

Plate 27, bottom. Titian, Venus and Adonis. 107 × 136 cm. Courtesy of the National Gallery of Art, Washington, D.C., Widener Collection (1942.9.84 [PA]).



Plate 28. Gerard David and Workshop, St. Anne Altarpiece, ca. 1506: left, St. Nicholas, 236 × 76 cm; center, St. Anne with the Virgin and Child, 236 × 96 cm; right, St. Anthony of Padua, 235 × 76 cm. Courtesy of the National Gallery of Art, Washington, D.C. Widener Collection.

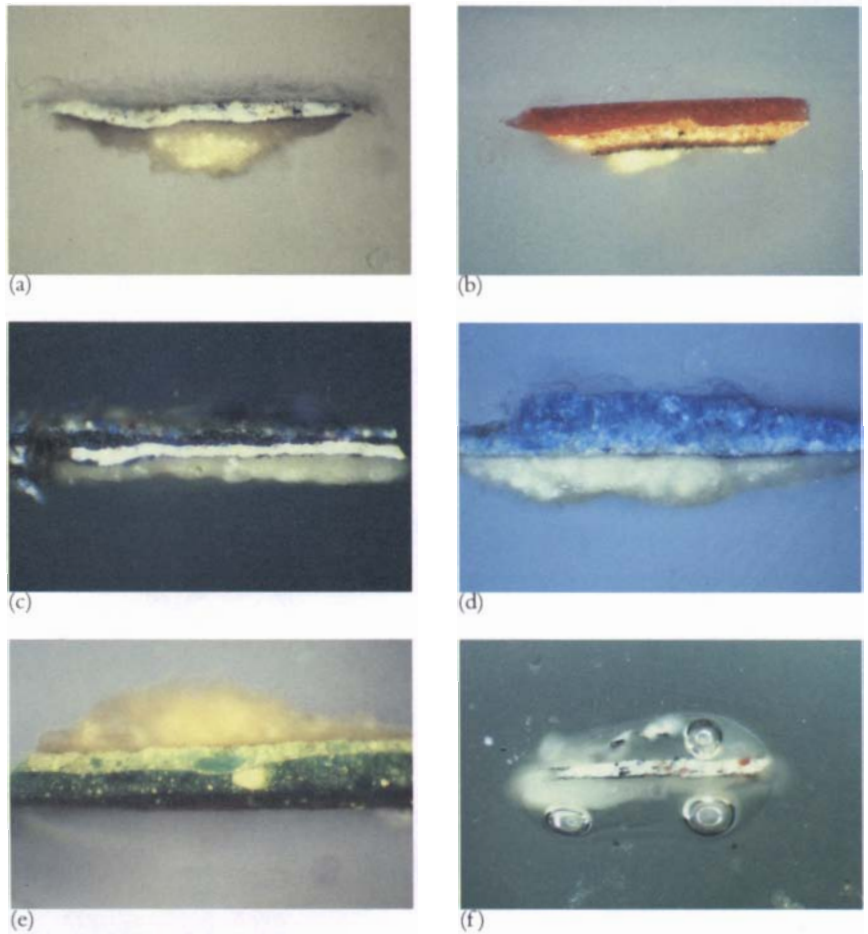


Plate 29. Cross sections of the St. Anne Altarpiece, shown in Plate 28. Cross section (a) through the underdrawing line below the cherub's foot (photographed at $\times 100$) shows four layers: ground, underdrawing, pale gray, and blue-gray. Cross section (b) through a line in St. Anne's red drapery (photographed at $\times 100$) shows multiple layers: ground, type III underdrawing, two layers of orange red, and multiple layers of red glaze (the layering is not observable in normal light). Cross section (c) through the "correction" layer in the Virgin's sleeve (photographed at $\times 100$) shows five layers: ground, underdrawing, pale underpaint, "correction" layer, and dark violet glaze. Sampling by B. Miller. Cross section (d) through the Virgin's blue drapery (photographed at $\times 100$) shows four layers: ground, underdrawing, pale blue, and dark blue. Cross section (e) through the dark green part of the cloth of honor shows seven layers: ground, scattered black particles, blue-green, dark green, dark-green and green glazes, and discolored varnish. Cross section (f) through St. Anthony's cassock (photographed at $\times 100$) shows three layers: ground, underdrawing, and violet-gray. Sampling by B. Miller.

Plate 30. Cross section from Baptism, near an edge: layer 1 (at the bottom), intermediate white layer, here thicker; layer 2, pink layer with madderlike particles; layer 3 (on top), white with natural ultramarine. Photograph by J. R. J. van Asperen de Boer.



Plate 31. Paint cross section, light green foliage, upper part of central trees. Workshop of Jan Bruegel, Noah's Ark. Layers from bottom: (1) chalk ground; (2) imprimatura: red and black in a translucent medium; (3) sky: white lead, pale smalt, black; (4) foliage underpaint: azurite, earth, white lead, black. Magnification on 35 mm film: $\times 64$.



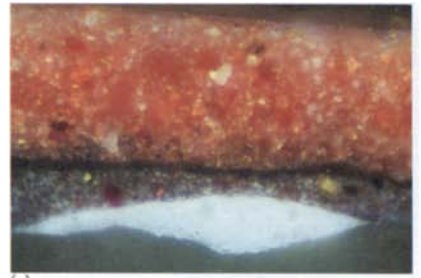
Plate 32. Paint cross section (dark sky at upper edge) from Esaias van de Velde's Winter Landscape. Layers from bottom: (1) ground: chalk with white lead, earth, and black; (2) sky: white lead, smalt, and earth black; (3) darker sky: smalt and white lead; (4) overpaint. Magnification on 35 mm film: $\times 70$.





Plate 33. Paul Delaroche, *The Execution of Lady Jane Grey*, 1833. Canvas, 246 × 297 cm. London, National Gallery (1909).

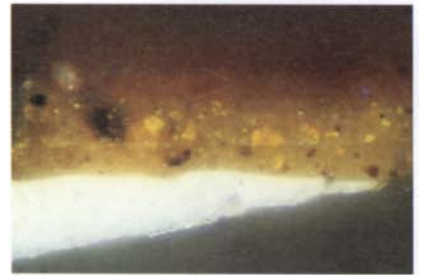
Plate 34a, b, c, d. Paint samples from The Execution of Lady Jane Grey: (a) cross section, pinkish red of executioner's tights, original magnification $\times 540$; (b) cross section, grayish shadow on Lady Jane's dress, original magnification $\times 750$; (c) cross section, red and brown brocade draped over lap of seated attendant left, original magnification $\times 750$; (d) unmounted fragment, black of Sir John Brydges's gown, photographed from the reverse at $\times 275$.



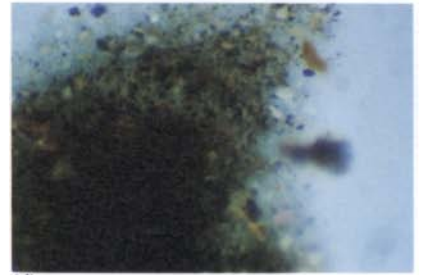
(a)



(b)



(c)



(d)

Plate 35, right. Detail from the lower left-hand corner of J. M. W. Turner's The Dawn of Christianity shows where Turner used the canvas to try out colors.

Plate 36, below. Detail of sheep from William Holman Hunt's Strayed Sheep (Our English Coasts), 1852. 432 × 584 mm. Courtesy of the Tate Gallery, London (N05665).





Plate 37, left. James Whistler, *Arrangement in Flesh Color and Black: Portrait of Théodore Duret*, 1883–1884, oil on canvas. Wolfe Fund, Catharine Lorillard Wolfe Collection, 1913 (13.20). © 1984 by The Metropolitan Museum of Art.

Plate 38, above. Detail of a reflection from Whistler's *Nocturne: Blue and Silver*, showing that the paint has been dragged horizontally when both the white overpaint and blue underlayer were still wet, to produce the effect of light on the water surface.

Abstract

This paper argues for an interdisciplinary approach to the study of artists' painting materials and painting practices. Recent research into British documentary sources on nineteenth-century oil painting reveals information useful in technical examinations of paintings. Examples illustrate how important a full understanding of the artist's physical environment and contemporary beliefs can be in accurately interpreting evidence from a painting.

Beyond a Collection of Data: What We Can Learn from Documentary Sources on Artists' Materials and Techniques

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Introduction

In the preface to the catalogue for the National Gallery of London's exhibition, *Art in the Making: Impressionism*, the sponsor remarks, "We see not just painted surfaces, but are given a multi-disciplined information which brings the paintings themselves to life" (1). The desire to know more about the whole object, to go beyond the image, the preface continues, to get "behind the pictures, and even through them," is very much a feature of our era, just as the delight in finding the "real" information hiding behind our conventional views fuels so many contemporary investigative endeavors in all disciplines. Our enthusiasm for complete knowledge is something we have in common with our predecessors of the late eighteenth century.

Fresh from the age of enlightenment, one author of a late eighteenth-century technical manual on oil painting writes in his preface (2):

Facts judiciously arranged, and published from time to time as they accumulate, are productive of infinite advantage. . . . Every branch of science is much facilitated and advanced by public communication, which distinctly points out the present, and opens a free channel to future discoveries. . . . Records of this kind act, therefore, as stimulants to general improvement: what is already known need not be retraced, and what is discovered in future [sic] may be occasionally added: thus, the needy and diffident will be taught with oeconomy [sic] and ease, and mystery will be unfolded and converted into truth.

Few today would argue for such a completely linear view of knowledge, but the desire to "know all" has not left us.

Nineteenth-century technical literature on oil painting materials and practices shows that the search for and collection of the "facts" was underway in earnest at that time. By the end of the century, however, we find the optimism somewhat chastened: all the new chemical knowledge, all the new facts, still could not provide oil painters with any guarantees, once and for all, for the durability of their work.

A similar sort of optimism existed for those in the twentieth century who examined the role of science in unraveling the mysteries of oil paintings. The belief was that with enough instruments and enough analysis, we could know the secrets of the old masters, we could know of what a painting is made. However, as one of our discipline's critics Michael Daly points out, "Such technical analysis can only ever say what a material is, never what its purpose was" (3).

Although scientific instrumental analysis is a highly sophisticated branch of inquiry in itself, results from it alone are not sufficient. It is only in partnership with other forms of investigation that we can hope to unravel the meaning behind what we find through analysis. Now, nearing the end of the twentieth century, having penetrated much of the "mystery" and converted it into truth, we find that the gifts of science are not enough. It is to "multidisciplinary information" that we turn in order to understand the purpose of the materials we find.

Fortunately, the spirit of the eighteenth century in Britain fired a great enthusiasm for publications on technical matters, including the materials and techniques of oil painting. Thus, we find a rich source of information in the various treatises, manuals, and handbooks that continued to be published into the nineteenth century. The following will be a discussion of the kind of information these documentary sources can provide and how this information can influence our interpretation of cross sections and analytical results as well as further our understanding of painters' techniques.

The painter's environment

The anonymous eighteenth-century author quoted previously placed great faith in "facts judiciously arranged, and published from time to time as they accumulate." Yet, however important a discrete piece of information, such as the date of introduction of a new pigment, may be in the study of painters' instruction books, it is not always this information that provides insight into the painter's choice of materials. Sometimes it is the tangential information about the experience of living at a given time that provides a context for what we observe now.

In cross sections of paint, the build-up of dirt between layers of paint must be interpreted in relation to past conditions for lighting and heating. We cannot, based on our present-day experience, extrapolate from the thickness of a dirt layer the length of time between episodes of painting. Here, those who study the history of technology and of domestic life are of great help. In one source on the history of domestic environments, we find that even as early as 1700 the use of coal for heating in London resulted in a "Tartanous Smoak" that sullied the environment both indoors and out: "All sorts of Hangings, especially the Tapestry, are in a few Years totally defil'd by it . . ." (4). Because painters who followed the technique of "painting in stages" were obliged to wait between applications of paint for the underlayers to dry, a fairly rapid build-up of dirt could be expected under the conditions described, far more than our late twentieth-century environments would convey.

The level of air pollution in the days of coal heating also caused great concern among artists and their chemist advisors with regard to the role of lead in paintings. It was thought that the high levels of sulfur in the air caused reactions with lead-white pigment and with lead-treated oil, resulting in an overall darkening of these materials due to the reaction product, lead sulfide. Various solutions to this problem, including the application of nonreactive zinc white over lead-white underlayers, were recommended. This advice to apply zinc white over lead white was given not only for paint layers, but for grounds as well; it was believed that a lead-white ground preparation could also be subject to darkening. Cross sections taken from a painting in which this advice had been followed show layers of two different white paints, the presence of which would not be immediately obvious without the knowledge of the remedial steps taken to obviate the so-called lead-sulfide darkening (5).

Aside from the dirt and soot from coal heat and tallow candles, interior environments were also substantially colder in the winter months. In the absence of central heating, painters found that their colors dried significantly more slowly during the winter months, hence the advice to add materials that hasten drying at this time of year (see below).

Beliefs influencing artists' practices

Artists' practices were also influenced by views and beliefs that are foreign to our era. Conservators have discovered empirically that it was not uncommon for nineteenth-century painters to use similar varnishes in the paint medium to those used as a final varnish. In the literature, painters were quite explicit; they believed that using the same resin in the medium as in the final varnish would, by ensuring homogeneity of materials, reduce the likelihood of cracking (6). In a pharmaceutical dictionary and recipe book published in 1764,

we find a description of the affinity of like materials that could well be the antecedent of this nineteenth-century practice (7).

The widespread addition of varnish to the oil painting medium was itself fostered by the belief that this was the method used by the old masters to achieve the particular translucent quality observed in their paint (8).

Seeing the past through present-day lenses

David Lowenthal, in his book *The Past Is a Foreign Country*, wrote (9):

However faithfully we preserve, however authentically we restore, however deeply we immerse ourselves in bygone times, life back then was based on ways of being and believing incommensurable with our own. We cannot help but view and celebrate it through present day lenses.

Just as we can enhance our understanding of artists' practices by learning more about the implicit assumptions they made based on the beliefs common to their era, we must be especially careful not to impose our own assumptions on the past. For example, the identification of fugitive colors in a nineteenth-century painting could lead to the conclusion that the artist knowingly opted for fugitive colors. Because information regarding which pigments were unstable was widely available at this time, the presence of these colors in a painter's work must mean that the painter did not "care" if the colors would fade. But this is not necessarily true; in fact, the painter may well have conscientiously purchased stable colors, but may have been unknowingly supplied with substituted materials by the colormen.

A thorough study of the literature, combined with scientific analyses of paint samples, revealed that in the nineteenth century the name of a color did not always offer a reliable indication of composition. Naples yellow is a good case in point. Traditionally a lead-antimony compound, by the late nineteenth century Naples yellow was reported to have been substituted with more reliable coloring agents: lead white and cadmium yellow. But the sample labeled Naples yellow in a Winsor & Newton oil-sample book actually consisted of lead white, red lake, and yellow lake. Since nineteenth-century lake colors were not particularly stable to light, this particular Naples yellow would be unlikely to retain its hue indefinitely (10).

Documentary research also indicates that media analysis sampling that is restricted to one color area cannot be assumed to apply to the whole painting. Early instruction books, in which the artists were still instructed in grinding their own paint, indicate that the paint medium would be changed according to the character of the pigment used. Because of its initial yellow color and because it was believed to after-yellow the most, linseed oil was generally recommended for dark colors, and the less-colored poppy and nut oils were reserved for light colors. There were exceptions, however. Lake colors dried slowly; therefore, linseed oil—the fastest of the three to dry—was recommended for use with these "light" colors (11). Drying oil in combination with copal varnish was recommended as the medium for Kings yellow or orpiment (12). Many other pigments received individual treatment and admixtures with varnish (13).

As we have seen, the choice of oil depended not only on the pigment used, but also on the season. Oils treated either by boiling alone or in conjunction with metallic compounds (driers) to hasten their drying time were sometimes recommended for the winter months only, when damp, cold weather lengthened drying time. Conversely, painters were warned that such treated oils would "in summer . . . dry so soon as to be troublesome" (14). Since the essential nature of oil paint had not changed by the early nineteenth century, it is not surprising to find this kind of advice appearing in print much earlier. In 1693 Marshall Smith recommended, "If in the hottest weather your greatest Dryers dry too fast, as White, Umber, &c and so grow too stiff to work with, you may prevent it by mixing a little Sallat Oyle with Colours" (15).

Just as we cannot extrapolate to the whole painting from media analysis in one color area alone, documentary sources indicate that the medium could change not only from color to color, but also from paint layer to paint layer. Once again, this was not confined to the nineteenth century. Marshall Smith instructed that lead white be mixed with nut oil, but noted that linseed oil could be used in dead-coloring (16). Advice to vary the medium according to the layer continued to appear in the literature, the faster-drying linseed oil again being recommended for underlayers such as dead coloring, with poppy or nut oil in the finishing layers (17).

Interestingly, the medium for the first lay or dead coloring need not have been oil at all. There were references to the use of watercolor, egg tempera, and a combination of two-thirds starch to one-third oil (18).

Contemporary experience with oil painting materials may also lead to assumptions that require examination. Today, if we wish to prepare a “traditional” lead-white ground, the first step would be to size the canvas using a hide glue such as rabbit-skin or parchment size. Although there are indications that the use of glue size, including isinglass, was common in the past, this was not the only material used. Starch was also employed as a size layer and appears in recipes throughout the nineteenth century. There were also indications that the addition of a plasticizer or humectant such as honey, sugar, or glycerine would not have been unusual. Near the end of the century, we find a reference to the use of collodion (cellulose nitrate) as a replacement for the size layer (19).

Our present-day lenses can also result in our underestimating the importance of materials that in our own day are no longer in use or have become precious and rare. Isinglass, a glue prepared from the swim bladder of the Russian sturgeon, is not widely available today. In eighteenth- and nineteenth-century England, isinglass was commonly used for a variety of purposes: to clarify beer, wine, and soup, and as a sizing agent for fabric, ribbons, and paper. Therefore, the presence of what is now quite rare, but was then a relatively commonplace glue in the size layer for an oil painting, is not surprising.

Another such material that has dropped out of use entirely is sugar of lead (lead acetate). A white crystalline powder widely used as a drier for oil paint, it was added directly to the pigment-oil mixture and was also present in medium recipes. Lead acetate could be purchased easily from apothecaries and appears to have been in wide use by painters in the late eighteenth and nineteenth centuries. By the twentieth century, however, it was never mentioned in sources on oil painting materials and techniques, although other traditional lead driers, such as litharge or metallic lead, do receive notice. As a result, the important role that this material played has never been acknowledged or studied in the twentieth century.

Conclusion

Although we must accept Lowenthal’s observation that life in the past was “based on ways of being and believing incommensurable with our own,” we should not see the exercise of studying past practices and materials as futile (20). Rather, we should equip ourselves with the knowledge that we are handicapped by our late twentieth-century standpoint. By making use of a variety of disciplines, by not concentrating our energies too much on only one avenue of inquiry, we can continue the search to “know all.” As much as possible, we should look outside of our immediate disciplines for researchers who are also mining the past, as it is this multidisciplinary approach that will enrich our understanding and interpretation of the “facts.”

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Abstract

Methods of art historical research, painting expertise, and scientific research can contribute to the detailed study of painting techniques. Conversely, the knowledge of painting techniques could support art historical research. The need for collaboration between individual disciplines during all stages of research is strongly stressed, from the initial formulation of working questions and hypotheses to final conclusions about the techniques of an artist.

An Integrated Approach for the Study of Painting Techniques

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Introduction

The study of artists' techniques in general and the study of an individual artist's techniques in particular are important for several reasons:

- (a) Art historians can use detailed knowledge of an artist's technique and its developmental evolution throughout the artist's career in the authentication process. This information can also aid in the establishment of a proper chronology for the known works of a given artist.
- (b) Artists of various historical periods were able to achieve specific visual effects by the use of special artists' materials or by methodical application of proven painting techniques. Because detailed documentation is seldom available today to help artists learn the steps needed to re-create a given visual effect, artists must rely on the results of systematic art research to learn old master techniques.
- (c) Museum conservators, in order to ensure a safe working strategy when planning a conservation or restoration treatment, rely on specific information about pigments, binding media, and materials, including those of earlier restorations, as well as detailed knowledge of the structural arrangements of these materials.

The art historian and art research

The role of the art historian in the realm of art research is critical. It is the art historian who must set the foundation, into which the information gathered by individual researchers of a painting-technique research team is organized, for final interpretation. In the study of painting techniques, two tools used by art historians are very important: connoisseurship and archival research.

Connoisseurship. Beyond establishment of individual and historical chronologies, connoisseurship itself—the expert knowledge of style and technique that the art historian develops through the course of a career—is of immense help in the research of artists' techniques. This keen sense of discrimination can be used to identify idiosyncrasies particular to a given artist's work. When drawn from works of undisputed provenance, the art historian can use the idiosyncrasies to establish a signature of style, materials, and techniques for any given artist. This “signature style” is critical for researchers in all the related disciplines. The signature style for a particular artist establishes the standard of measure against which all data can be judged.

Archival research. The study of primary documents—such as municipal, guild, or financial records and chronicles in which artists' names can be directly located—provides crucial information about artists' lives, training, professional and social standing, and other socio-economic factors that influenced the development of their working methods and personal painting styles. When an artist's notes, letters, books, diaries, and travel journals are available, the study of these materials often provides important information leading to

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knowledge and understanding of the artist's intent, as well as the rationale behind the use of a particular material and painting technique.

The study of primary sources—such as books and treatises on painting, old recipes for the preparation of artist materials, and guild practices and procedures—can contribute to our understanding of the artists' working environment. The study of such documents can be invaluable, but extreme caution should be applied when interpreting old manuscripts. A number of misunderstandings have arisen because of the often confusing nomenclature used in old texts and recipes and the distorted facts found in old biographies of artists. Even so, the study of secondary documents, such as biographies of painters, provides important information of the creative, social, and economical environment in which the artist worked.

Artists and art research

A painting is composed of elements that can be separated for study. As there are schools of artistic thought, there are schools of painting technique. Each school of painting technique has a specific procedural approach to painting construction. Although there are many elements common to all painting techniques, there are also specific elements unique to each. It is possible to isolate and define these unique qualities for each technical approach and to establish markers for a detailed study. These markers, when encountered during an examination, provide keys to the likely construction of visual effects within the piece.

An initial, standardized visual examination of a painting by an artist specializing in painting techniques can aid in any art historical or subsequent scientific investigation, not only helping to orient the researcher but also assisting in the interpretation of the results. If, for example, it was determined through visual examination that a particular piece was a multilayered, glazed construction on panel, it might then be assumed, based on knowledge about the particular technique, that the piece would have an oily imprimatura on a gesso ground. Knowing this beforehand, a researcher who discovered an oily component in the ground layer might investigate the possibility of its having been absorbed from the imprimatura by the lean ground rather than assuming the discovery of a novel gesso recipe.

Technical approaches used for creating the illusion of volume

A basic goal of all representational artists—to present an illusion of volume—is accomplished in painting through the juxtaposition of dark and light values, and of highlights and shadows. This illusion is accomplished traditionally through one of four basic techniques. A brief analysis of these techniques will illustrate the possibilities of standardizing the visual examination of paintings and the usefulness of the visual markers that can be established as a result of this approach.

Basic technique. In a direct approach, dark and light values are placed by single, individual brush marks onto the surface of the painting. There is no blending of the pigments themselves. Dark values are used to indicate shadow and light values to indicate highlights, effectively indicating volume. Despite the obvious simplicity of this approach, it can be highly successful. The tempera paintings of the Italian Trecento illustrate the effectiveness of this technique.

Visual markers for this technique include a uniform surface of clearly defined, individual brush strokes that retain their original distinct color and do not physically blend into surrounding pigments (Plate 1a, b).

Transparent oil technique. This more complex, systematic approach, which was developed with the advent of transparent oil media, is exemplified by the Flemish and early Netherlandish masters. These artists conceived of the painting from its inception as a multilayered object with a structural separation of color and form. Volume, developed through highlights and shadows in a monochromatic underpainting, was followed by color embellishments.

Well aware of the optical properties of both light and color, the artist worked on a highly reflective, white ground layer. The underpainting could be a complete gray-toned version of the finished image, painted in a manner such as that described in the preceding basic technique. It could also be constructed through a more sophisticated technique, as seen in the unfinished panel of *Santa Barbara* by Jan van Eyck. An underdrawing, which establishes contours and darks on the white ground layer, is covered with an *imprimatura*, a thin, transparent layer of paint that allows the drawing to show through the ground while also establishing a middle tone throughout the painting. Highlights could then be added in white paint where appropriate, thus, with less work, completing the values and creating a finished monochromatic underpainting.

Regardless of the approach taken toward the underpainting, its creation was essential to the technique itself. Color applied as thin transparent glazes allowed the fully developed underpainting to define the forms while the color itself remained clean, pure, and unadulterated. Highlighted areas could be achieved with the thinnest possible application of local color, as the white of the underpainting had merely to be tinted appropriately. Dark tones, however, posed some problems with the clear transparent pigments: many layers were required to cover the underdrawing and establish the proper local color.

By focusing on these highlights and shadows, visual identification of the technique is quite simple. Highlighted areas are very thin and fine. Color applied in thin glazes tends to be clear, luminous, and devoid of brush marks. Shadows and dark colors, however, appear as thickly built-up surfaces, creating ridges clearly visible in raking light where they come into contact with the delicate light areas (Plate 2a, b).

Highlighting with impasto white. Allowing a freer painting style and facilitating larger formats, this more flexible technique is typical of the Baroque masters. Any support suffices; the underdrawing is optional. The artist tones the surface with a middle or darker value, then creates the image with an underpainting of washes that may be controlled or completely free and spontaneous. The areas of the painting to be highlighted are now created with a heavy impasto white paint.

This simple procedure accomplishes the same optical effects as the complete monochromatic underpainting of the previous transparent oil technique, yet it allows the image to evolve as it is constructed. The continued separation of value from color still allows for beautiful luminous color. Because the image originates in the loose, dark washes, contours need not be highly defined and extreme *chiaroscuro* is possible. The resulting work is often quite dramatic in nature.

This technique provides very specific optical markers. The darks are thin and transparent, often revealing the preliminary wash or *imprimatura*. The highlights that define the volume appear thick and visibly raised from the painted surface (Plate 3a, b).

Direct surface blending. In the controlled technique of surface blending, individual colors and values are mixed and applied to appropriate locations of the surface to indicate highlight and shadow. Each new application of color is carefully blended into the surrounding paint, resulting in a smooth, continuous flow. The underdrawing and underpainting serve only as a guide for the surface painting; they do not actively affect the surface itself.

All traces of brushwork can be blended out if desired; consequently, the technique lends itself well to smooth, detailed, controlled styles such as found in the work of the Neoclassicists.

Visual markers for the technique include a smooth, continuous surface with gradual, imperceptible shifts from highlight to shadow. Direct blending of the pigments creates an opaque quality in contrast to the luminous character of colors in the multilayered approaches (Plate 4a, b).

Table 1. Scientific methods used for identification of critical, unaltered parts of a painting.

Method	Information	Limitation
observation under UV light	dark areas repainting in comparison with light areas of heavily oxidized oil paints (autofluorescence)	- does not work for all binding media - possible interference with some varnishes
UV photography	documentation of repainted areas	as above
false color infrared photography	identification of repainting if done using pigments of the same color but different chemical composition	only for orientation, should be confirmed using other methods of chemical analysis
X-ray radiography	localization of support alterations, ground and paint layer repairs and alterations	high contrast only for heavy chemical elements (Pb, Hg, Au)
X-ray fluorescence spectrometry (XRF)	- identification of repainted areas if done with inorganic pigments of different composition than original (e.g., zinc or titanium white instead of lead white) - a non contact analysis	- possible difficulties with mixed pigments and complex multilayer paint structure analysis - no analytical information for low atomic weight elements ($Z \leq Na$)
microchemical methods (polarized light microscopy, chemical microscopy, electron microprobe, X-ray diffraction)	identification of repainted areas based on pigment identification	- microsampling of paint material needed - uncertain identification of some organic pigments and dyes

The visual traces left by the physical manipulation of painting materials on paintings can be identified for study. Idiosyncrasies of color, brushwork, paint consistency, form, and so on can each be evaluated to reveal specific unique qualities within given predefined techniques. This information can then be used for the general analysis of historical paintings. The works of individual artists can be analyzed in a similar manner, identifying a signature style and painting procedure through specific visual clues.

The role of scientific and technical examinations

The process of applying scientific methodology to the study of painting techniques can be divided into the following three major steps: (1) identification of the critical (unaltered) parts of the painting, (2) authentication of the painting, and (3) study of detailed physical and chemical structure of paintings.

Identification of the critical (unaltered) parts of the painting. The majority of paintings in museums or private collections have a long history of cleanings, restorations, and alterations. Before embarking on a study of painting techniques, it is essential to identify areas of the painting in which the painting technique of the original artist has not been altered by later treatments. Scientific methods for such a study are described briefly in Table 1.

Authentication of the painting. When a series of paintings by a particular artist is examined with the goal of studying painting techniques, it is crucial that the authorship of the pieces is established “beyond a reasonable doubt.” Scientific research cannot establish the relationship between the artwork and the artist. What scientific research can do very successfully is to effectively eliminate paintings that, based on clearly defined scientific facts, could not have been created during the active life of the artist in question. Several powerful scientific methodologies that can be used to help authenticate paintings are described in Table 2.

Study of detailed physical and chemical structure of paintings. Usually, only the top paint layer, with its corresponding brushwork and surface treatment, is accessible to visual observation. This is a very severe limitation when studying painting techniques because before the *alla prima* technique became widely used during the second half of the nineteenth century, the majority of paintings were created in complex multiple-step and multilayer processes. Table 3 shows several scientific methodologies that can be used in probing and analyzing such painting structures.

Table 2. Scientific techniques for the authentication of paintings.

Method	Information	Limitation
visible observation and X-ray radiography	visible and hidden tool marks; materials (machine made canvas, nails, etc.)	- knowledge of ancient technologies required - new repairs may pose a problem
pigment chronology inconsistency studies (microchemical methods)	identification of the systematic use of pigments in the painting which were not available in times when the painting was presumed to be painted	- detailed knowledge of pigment chemistry and technology required - problem of interpretation when only repainted areas analyzed - the negative results cannot be considered a certain proof of authenticity
radiocarbon dating	absolute dating method of the actual age of natural product organic materials in paintings (wood, canvas, binding media)	- does not provide good results for materials younger than 300 years - problems of impurities
dendrochronology or tree ring dating	absolute dating method actual age of wood samples	quality sample containing a number of easily measured tree rings and corresponding calibration data is needed



Figure 1. Diagram of integrated approach for the study of painting techniques.

Conclusion

Art historians, conservation scientists, and artists use different means to study artists' techniques. Each of their approaches can contribute valuable information about the painting techniques of an individual artist, a school, or an art historical period or movement. But each approach leaves something unexplained, something missing from the whole picture that encompasses everything from the artist's brushwork to preference for certain materials and formulas. To provide a real understanding of artists' techniques, it is necessary to establish a close collaboration between all the above-mentioned disciplines, not only to secure a more complete set of data but, more importantly, to stimulate interdisciplinary formulation of more holistic answers about artists' techniques (Fig. 1). A painting should not be studied by individual specialists from each discipline, but rather by representatives of all disciplines who view

Table 3. Scientific methods used for the analysis of painting structures.

Method	Information	Limitation
infrared reflectography	identification and study of underdrawing	difficult to identify underdrawing beneath thick layer of IR-opaque paint layer
X-ray radiography	study of support, lead white underpainting, brushwork, and changes in composition	- superimposition of several layers of painting in one X-ray radiograph - difficult interpretation for features done in organic materials or pigments of low atomic number
X-ray tomography	detailed study of individual paint layers	- methodology under development - high cost - problem of interpretation when individual paint layers are of uneven thickness
cross section analysis (microchemical methods, IR microscopy)	detailed material identification (pigments, binding media) and sequence of individual paint and material layers of the painting	- cross section sample needed - high cost of analysis - positive identification of some organic pigments might need additional sampling, followed by organic microchemical analysis - additional sampling might also be needed for detailed analysis of binding media using gas chromatography - mass spectrometry

the painting together, share background information, and actively collaborate in formulating a working hypothesis, work strategy, and research goals. Successful research calls for broad international and multidisciplinary collaboration when art technique findings are used for authentication purposes.

Abstract

This paper provides an overview of technical aspects of the search for verisimilitude in seventeenth-century Italian painting. In particular the role of varnishing will be examined in relation to technical problems caused by absorbing grounds. In addition, some theories on viewing distance and lighting will be discussed.

Varnish, Grounds, Viewing Distance, and Lighting: Some Notes on Seventeenth-Century Italian Painting Technique

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Introduction

In the sixteenth century, the dichotomy between *Disegno* and *Colore*, between Titian and Raphael, was seen as one between those artists who chose to imitate nature and those who chose the Antique as their model. In the seventeenth century, this dichotomy could be reduced, simplistically speaking, to two groups of artists: those who were more strongly influenced by Raphael and the Antique and who painted with a smoother, apparently more finished technique; and those who were more influenced by Titian and the Venetian school of painting and the more open texture that accompanied this type of representation of naturalistic effect—what Poussin's friend Du Fresnoy termed “the great Lights and Shadows, the Effect of the whole together” (1). These two tendencies have been seen to coexist through the end of the nineteenth century.

Although these two schools differed in their approaches to handling paint, they both subscribed to the idea that painting should be the representation of natural appearances on a flat surface; and most importantly, that through this representation the public should be able to grasp a higher and greater truth. Ideas as to what form this imitation of nature should take varied, but the essential concept can be found in the writings of theorists as divergent in other respects as the arch-Venetian Boschini and Bellori, the epitome of Roman Classicism (2, 3).

The first Academy of Painting, founded in 1586 by the Carracci in Bologna, was crucial to the development of painting in seventeenth-century Italy. Painters such as Domenichino, Reni, Albani, and Guercino (as well as Annibale Carracci) who had come to Rome after training at the Carracci Academy profoundly influenced their contemporaries in Rome. They brought not only the teachings of their masters (i.e., that the painter had to emulate nature accurately on a flat surface, while also illustrating the essence, the “Truth,” of what was depicted, that which was beyond simple appearances). This concept, essential to painting in its newly reacquired status as a liberal art, was also in complete accord with the tenets laid down by the Counter-Reformation. Two camps emerged concurrently: those who described the thing itself, and those who described the impression on the beholder.

St. Philip Neri and Paleotti both required that artists, through verisimilitude or realistic representation, appeal to the hearts and minds of the people.

This paper provides an overview of technical aspects of the search for verisimilitude in seventeenth-century Italian painting. In particular the role of varnishing will be examined in relation to technical problems caused by absorbing grounds. In addition, some theories on viewing distance and lighting will be discussed.

The use of varnish

André Félibien, who moved in the artistic circles of Rome in the 1640s and who was a friend of Poussin, Guercino, and Cigoli, and probably knew Galileo, wrote, “When a work is painted to the last degree of perfection, it can be considered from close to [sic]: it has the advantage of appearing stronger and three-dimensional” (4). This same effect, wrote Félibien, can be created

by distance with “the aid of the air interposed between the eye and the object, using different distances,” or by the application of a varnish “which is why we cover paintings with a varnish that blunts that brightness and sharp edge [*qui émousse cette pointe brillante et cette vivacité*] which at times appears too strongly or unevenly in freshly painted works; and this varnish gives them more strength and softness [*douceur*]. . . . We use all these different methods to give painted objects that relief, that roundness that they require in order to resemble what one is imitating” (5).

Marco Boschini, the Venetian art theorist who in 1660 published his poem on the art of painting, “La Carta del Navigar Pitoresco,” had a low opinion of the glossy varnishes which he says “foreigners” used: “They make such a commotion about it, that it would seem that gloss is the only beauty, and varnish the apogee of art” (6). Later in the poem, he makes the distinction that is central to artistic theory and to seventeenth-century Italian artists in Venice as well as Rome. Comparing the aforementioned “foreigners,” Boschini praises the Venetian painter for imitating the effects of gloss (in armour and mirrors) in paint, rather than resorting to the use of varnish to produce this effect physically on the painting’s surface, writing, “li ha fatti straluser co’i colori” (he has made them gleam with his paints).

As Boschini wrote, “diligent painting can be copied,” but not what he termed the *colpi di dottrina* (which rather defies translation). It is the element of skill that is paramount, rather than the materials.

A high-gloss varnish may have been a requirement of northern seventeenth-century artists, at least according to Boschini, but this paper investigates the role played by varnish in Italian paintings of the same period, both those requiring “close scrutiny” and those “made to be seen from afar,” as Horace discussed, distinguishing these two kinds of fundamentally different paintings, when pleading for flexibility in the judgment of poetry, saying that it should be judged like painting which exhibits not only a detailed style that requires close scrutiny, but also a broad impressionistic style that will not please unless viewed from a distance (7).

Interesting information on the use of varnish in seventeenth-century Italian painting can be gained from the highly illuminating lecture entitled “Il Lustrato” delivered on 29 December 1691 by Filippo Baldinucci to his colleagues at the Accademia della Crusca in Florence. He dealt with the subject of varnish in contemporary painting as opposed to its use in ancient times and in the fourteenth century (8):

What we are told of the practices of painters in antiquity leads us to believe that they did not use oil as their medium; what we are told of the practice of Apelles always remains with me, that is, that he found a certain dark color [9], or maybe a varnish, which no one was able to imitate. This varnish he applied to his works after he had finished them, and with such a skill that the bright colors did not offend the eye and appeared from afar as through a glass (and please take note of this detail). Harsh colors acquired through it an element of austerity, of saturation. This is precisely what our painters in the fourteenth century did, before the discovery of oil as a medium; that is, they applied a varnish to their panels, which was of a composition that gave their languished paintings a certain depth and added strength, and by dimming the overpowering highlights, brought the whole closer to natural appearances. And then if you hear it told that modern painters sometimes also use a varnish on their oil paintings, I reply that such practice (which is confined to a few painters) is not to make up a deficiency in oil painting—that is, to bring depth to the dark colors, and render the highlights softer and less garish—things of which oil painting has no need, but rather to remedy an accidental mishap. This can occur because of the imprimatura, the paint mixture which one applies to the canvases or panels, or because of a defect of the canvases or panels themselves. They attract the oil liquid so strongly, almost stealing it from the

paint, that the paint remains drained [prosciugato], so that it can no longer be seen evenly on the surface, as would have been the case when such an accident would have been prevented. By means of another unctuous substance, which is the varnish, applied to those areas where the oil is missing on the surface (and this is the crux of the matter), the dark colors are made to reappear. These are the dark pigments which are really present in the oil painting, not those darks that just appear dark but are not physically present, as was in fact the effect created by Apelles's varnish in some very small areas on his paintings.

Many of Baldinucci's points require and deserve investigation; I will confine myself to examining his assertion that varnish in his time was applied as a retouching remedy locally rather than over the whole work (as the oil medium itself provided the saturation required to "bring the whole closer to natural appearances"). I shall also follow up his point linking this localized "sinking-in" with absorbency of the ground layer.

We are indebted to the Englishman Richard Symonds, an amateur painter who spent 1646–1647 in Rome, for the very detailed and painstaking notes he took while watching Gian Angelo Canini painting in his studio. Canini was a friend of Poussin's, and like the latter, trained in Domenichino's studio in Rome.

Symonds describes on several occasions that portions of Canini's paintings were "sinking in" (prosciugated), and he also described the remedies that Canini applied. Giving an account of the painting of a portrait of Sir Thomas Killigrew, he describes how: "the face and field were prosciugated . . . notwithstanding oyle was putt upon the back side of the cloth." This he blamed on the fact that the "cloth" (and he marked "imprimatura" in the margin) "was not as perfectly dry as it ought. I askt him how he would fetch the colour of the face, he sayd he would give it a semplice chiara d'uovo [egg-white] beaten together . . . or olio di sasso, another varnish" (10).

Elsewhere, Symonds describes Robert Spenser's portrait, painted in one sitting by Canini (11):

The scarf which was crimson he did with lacca / biacca [lake and lead white]. The whole scarf being done, and afore it was dry he putt on gold colour for the fringe, all which kept his fresh colour and needed no varnish. Not three days after, when one would thinke it was scarce dry he with a pencill of setola [hog] putt on his varnish over the first field & face & Armour & hands, but not the scarf or benda, / this kind of varnish he esteemed above that of Olio di Sasso.

For the preferred varnish, he gives the following recipe on f.20: "2 oz. of seven times distilled aquavita (spirits of wine) 1/2 oz. of ground sandarac 1/2 oz. of olio d'Abezzo [Strasbourg Turpentine]." This "final" varnish was only applied to those areas which he felt required it. He was also quite clear that certain pigments should not be varnished.

Symonds questioned Canini about the sky in a monumental painting that he executed on the subject of Anthony and Cleopatra: "2 days after the Azzurro ayre was dry, and I askt him what if it should prosciugare [sink in], so much the better said he, because you never put vernish over azzurro" (12).

The reason for this answer may be in the yellowing characteristics of the varnish or in a deliberate choice for the matte quality of the blue with a consequent increase in scattered reflection, and of the white component in light. This effect, to be avoided in darks, but desirable for achieving the effects of aerial perspective, was advised by Leonardo in his treatise on painting. One should not forget that all the artists in Poussin's circle had a strong interest in optical matters, and studied mathematics and optics with the best mathematicians; in addition, Galileo moved in this same circle.

Canini was also aware that certain pigments, such as blacks, caused problems by drying matte: "Black, even varnished, sinks in," meaning that unless cor-

rected, shadows would appear matte and therefore cool and come forward rather than giving the intended effects of depth (13).

Armenini is also aware of this problem. In his *De' veri precetti della pittura* (1587), speaking of shadows and contours he says: "They never remain sufficiently finished . . . but will always sink in, or the darks become cruder so that it is necessary to come back to them many times in order to make them fresh, blended, soft, and pleasing" (14).

Absorbency of the grounds

The problem of overabsorbent grounds, which is identified by Baldinucci as the cause for localized applications of varnish, is also a problem that reoccurs in Symonds's notes and obviously concerned Canini and presumably the other artists in this circle.

Almost all of the samples taken from paintings produced in central Italy circa 1600–1800 showed the presence of chalk in varying but significant proportions. Sometimes chalk was found as a single ground layer, as in the case of Domenichino's *Vision of St. Jerome* of 1603 (National Gallery, London); in Annibale Carracci's *Boy Drinking* (Christ Church Gallery, Oxford) which probably dates from the end of the sixteenth century; and in the much later Cavallino, *Christ Driving the Traders from the Temple* (National Gallery, London).

This type of ground derives from Venetian painting and is found, for instance, in Titian's *Madonna and Child* (ca. 1525), in which what appears to be the dark ground is in fact the saturated color of the canvas. The refractive index of chalk is so low that it is almost completely transparent when associated with oil.

Not enough analyses have been carried out to ascertain whether the chalk was applied in an aqueous or oil medium. More often the chalk is found mixed with earth pigments and small inclusions of other pigments such as charcoal black, or with driers such as lead white or an umber, as is the case with Caravaggio's works in the National Gallery in London (15). In a thin section taken from Poussin's *Finding of Moses* (National Gallery, London), one can see that the absorbency of the ground was recognized and an isolating oil layer applied. The sample was taken from a blanched area, in which both the ground and the paint film were very lean. Interestingly enough, in other areas containing lead white, the paint film was less lean and less absorbent.

Symonds wrote, "It is good to give a mano [hand] of gesso first, and then oil on top." Earth from which bricks are made is ground and used for the imprimatura, Symonds wrote, recording the recipe for the ground favored by Canini: After sizing the canvas, he applied a mixture of "red earth, a little white lead, a little charcoal black, and chalk" (16). Until now the latter seemed always to have been interpreted as white clay, although brick clay seems perfectly adequate. This mixture was applied to the canvas in an oil medium. The absorbency of the ground seems to have been both feared (because of the problem of sinking in) and desired (because it kept the colors fresh). As Symonds wrote, "These cloths that have gesso in their imprimatura—the gesso makes the colour keep fresher and does drink up the evil of the oil, but they crack sooner, and that is the worse of the gesso" (17). The sinking-in of colors, Symonds's "prosciugare," seems to be linked in their minds to the poor drying of the ground, either because the commercial primer left out the lead white for economy's sake (18), which seems to reduce the porosity of the paint film, or because it had not dried sufficiently before the painting was executed.

Then, as today, the poor drying qualities of earth pigments were recognized but not fully understood. From analyses we know that when the pigment in the oil film is an earth color, there is a surprisingly high percentage of scission

products in the dried oil film (19). These short-chain scission products, by giving the structure a swollen matrix, confer flexibility to the oil film. Earth pigments are then particularly suitable as grounds on flexible supports. To speed the drying process of these grounds, artists advocated the use of pre-polymerized oil (20).

Most of the inorganic components of these colored grounds are hygroscopic and are not easily wetted by organic media. Free fatty acids in the oil would act as surface active agents, and therefore an unpolymerized oil would be preferable to ensure wetting of the particles and pigment aggregates.

Groen and Burnstock have found air pockets with earth pigments bound in unpolymerized linseed oil (21, 22). This problem can only be aggravated by the use of an oil with a reduced proportion of free fatty acids (23). The presence of air pockets makes the ground porous, causing the paint layers above to “sink in” as the paint medium is drawn down into the absorbent ground.

Speedy drying achieved by applying the ground as an emulsion, as advocated in Pierre Lebrun’s *Treatise*, would also result in a porous film because of the voids formed during evaporation of the aqueous phase (24). The absorbency of the ground would be particularly problematic with artists such as Guercino who, in his first phase, painted *alla prima*, using the dark ground for his shadows and often applying only one layer of paint. Malvasia, describing Guercino’s technique before the artist left for Rome, says that Guercino had “an extraordinary speed of execution, in one go laying-in (*bozzando*) and finishing” (25). In the case of Guercino, the complaints came from his clients who felt that since they paid Guercino by the figure, they wanted to see the whole figure, not one in which more than half was drowned in shadow.

Lanfranco and later Giordano were also known for their speed of execution. This speed was castigated by most art theorists, because it was seen as *pratica*, simple manual facility rather than the fruit of matured intellectual thought and skill.

Exposed or thinly covered porous grounds would pose a problem when it came to varnishing (for the restorer as well as the artist), but grounds suffering from what the French call *lithargeage* present a similar problem in appearance. The coarsely ground lead white would present a less absorbent ground, but the rough granular surface scatters light, obscuring detail in the worst cases and flattening the composition. Many seventeenth-century paintings suffer from this problem (26).

Viewing distance and lighting

It is clear that in a painting such as Guido Reni’s *Abduction of Helen* (Louvre), which does not depend on the warmth of its shadows for the depiction of depth and its illusion of space but rather on what Leonardo termed aerial perspective and the diminution of colors, the impact of lithargeage is minimal, and saturation of the picture surface not essential.

This is the case with paintings of what I have termed the “high finish” school; that is, those by painters who did not paint *alla prima*, nor availed themselves in the Venetian manner of the artifice of large areas of shadow and light, but rather achieved the illusion of space through “the diminution of the hues, as much through their quality as through their strength” (27).

The relative importance of saturation in paintings that rely on their dark ground for illusion of space was especially visible in a recent exhibition of Neapolitan painting in Bordeaux. Two paintings by Caravaggio were hung next to each other. One was a privately owned *Doubting Thomas*, with a high gloss varnish, and the other painting was a *Salome with the Head of St. John the Baptist* (National Gallery, London), which had a much more matte appearance (28).

The differences in saturation, clearness of detail, and illusion of space were very clear at a normal viewing distance. If one stepped back far enough to be able to see both paintings, the detail and saturation of the two works appeared to be the same, and both surfaces had a matte appearance. The very effect of the air interposed between the eye and the object was alluded to by Félibien. According to this phenomenon, first objectively described and explained by Leonardo, objects in the distance will appear more blue because of the interposition of the tiny particles contained in the air.

The warming, darkening effect of varnish, that of light transmitted through the varnish, will be counteracted by the blue quality of the reflected light. This means that with paintings executed to be seen at a distance, a glossy saturated varnish would be unnecessary; at the correct viewing distance, the painting will appear somewhat matte.

Boschini, characteristically, writes, “Do you think painting is enjoyed more directly under the eye or from an appropriate distance? Certainly at a distance; because once you have hung the pictures and placed them at the wanted height, there’s no reason for you to go clambering up there” (29).

Another variable that is too infrequently considered when exhibiting paintings is the lighting. Paintings from that period were never painted in uniform daylight, nor were they to be seen in such conditions. Daylight would have been directional, and artificial light would have been warm candlelight. Restorers sometimes have the opportunity of lighting the painting with tungsten lights from the direction in which the painting was executed, and the effect in increased naturalism and illusion of space can be quite dramatic (30).

This is not a new observation. In 1628, in a text on the artist Cigoli, the biographer Comodi wrote about Cigoli’s *Martyrdom of St. Lawrence*: “It appeared much more admirable in the room in which it was painted which, receiving little light through a small window, was indeed in proportion both with the handling and with what was represented in the scene. Having seen the painting in this room several times, and seeing it again in the open air, he said to himself: ‘This just is not the same, even though everyone praises it also out here’ ” (31).

Viewing distance is also crucial for works executed with a painting method that defies legibility at close scrutiny. This is what we now may revere as the “magic” of painting, but to Poussin and his circle it came close to *pratica*, manual skill not guided by the intellect and therefore “inferior” and not worthy of painting as a liberal art.

Rather surprisingly, Bellori appreciated the skill involved in producing effects to be appreciated from a distance. In his biography of Luca Giordano, speaking of a *sotto-in-su* figure of Christ, he describes how Giordano would constantly descend from the scaffolding to check on the effect of his painting and the “huge brush strokes” and “coarse and garish highlights in the blue drapery,” which the distance of the eye blends and harmonizes together so beautifully and makes one understand how great his mastery is” (32).

Boschini’s poem, a eulogy of Venetian painting and technique, extols the *macchia* of which the “high finishers” are so scornful. He carefully distinguishes this from the rapid, sketchy *alla prima* technique he terms *prontezza* (33). He, too, emphasizes the skill involved, rather than the material aspect. The Venetian *macchia* “is what unites the wet paint with the dry paint beneath, which is so important to the beauty of this way of painting” (34).

Like Armenini and Félibien, he emphasizes the handling of the paint and the color, rather than its nature and strongly argues that painting should appeal to the mind and not the eye—that the spectator must see the hand inside the glove, while the eye only sees the glove (35, 36).

This brings us back to the essential message of the Counter-Reformation and of the new stature of painting as a liberal art: to convey essential truths

representationally so as to appeal to the heart and mind as well as to the senses. As Horace said, “Painting should instruct as well as delight by the two ways open to it: close scrutiny or distant viewing.”

Notes

1. Du Fresnoy, C. 1750. *Observations on the Art of Painting*. Dryden translation, first published in 1667.
2. Boschini, M. 1660. *La Carta del Navegar Pittoresco*. Venice.
3. Bellori, G. P. 1672. *Le vite de' Pittori, Scultori e Architetti Moderni*, first published in 1672. Pisa 1821 edition.
4. Félibien, A. 1685. *Entretiens sur les vies et les ouvrages des plus excellents peintres anciens et modernes*, 2nd ed. Paris. Vol. 2, Entretien VII:240.
5. *Ibid.*, 242.
6. This passage in a different translation is quoted by Robert Ruuhrs in his article “Matte or glossy? Varnish for oil paintings in the seventeenth century,” which appeared in an English translation in the *ICA Newsletter*, Oberlin, Ohio: November 1985. The article was originally published in *Maltechnik-Restaur* in July 1983: “E i forestieri certo in quella parte / Fa tanto cavedal, che la lustrezza / A lorighe par l'unica bellezza. / Ghe par che la sigila tuta l'arte.”
7. Horace. *Ars Poetica*. 361. See Lee, R. W. 1940. Ut pictura poesis: the humanistic theory of painting. *The Art Bulletin* (XXII).
8. Baldinucci, F. 1692. *Il Lustrato*. Paper presented at the Accademia della Crusca 29 December 1691 and 5 January 1692. Florence. On page 25: “Trovansi bene notizie di Pittori antichi, che fanno credere, che tale uso non vi fosse; fra le quali potrà sempre appresso di me ciò che fu scritto d'Apelle, cioè, ch'egli fu ritrovatore d'un certo color bruno, o vernice che si fosse, la quale niuno seppe imitare, e davala all'opere dopo averle finite; e che servivane con tanto giudizio, che i colori accesi la vista non offendevano, facendoli vedere da lungi come per un vetro (e notate questa particolarità) e che le tinte lascive, mediante quella acquistavano un certo che d'austero, o di scuro, che è tutto quello appunto, che facevano i nostri pittori del 1300, avanti il ritrovamento della tempera coll'olio, cioè, che davano sopra le tavole una vernice, che era una certa mestura, che alla loro dilavata pittura un certo che di più profondo, e di forza maggiore aggiungeva, ed il soverchio chiaro alquanto smorzando, riduceva a maggior somiglianza del naturale. . . .” On page 31: “Se poi sarà detto, che i moderni Pittori usano anch'essi talvolta vernice sopra le lor pitture a olio, io rispondo, che tale usanza—ch'è di pochi—non è per supplire al mancamento della pittura a olio, cioè, per render più profondi gli scuri, e i chiari più mortificati, e più carnosì, cose tutte delle quali la pittura a olio non ha bisogno ma bensì per rimediare ad un'accidental disgrazia, che occorre talora a cagione dell'imprimatura, mesticata, o altro che dassi sopra le tele, o tavole, o pure proviene dalle medesime tele, o tavole, cioè d'atrarre così forte il liquido dell'olio, quasi rubandolo al colore, ch'e' venga in qualche luogo prosciugato per modo, ch'e' non possa farsi vedere in superficie per tutto ugualmente, com'egli avrebbe fatto col cessare di tale accidente; con che per mezzo d'un'altra cosa untuosa, che è la vernice data dove l'olio in superficie mancò, fassi apparire (e questo è il punto stretto e forte) con che fassi apparire lo scuro, che già nella pittura fatta a olio veramente è, non quello che non v'è, ch'era appunto l'effetto, che in qualche piccolissima parte faceva alle sue pitture la Vernice d'Apelle.”
9. In Italian, the word used is *bruno*. It should be noted that *imbrunire* is the word used for burnishing gold, that is, making it darker and increasing its sheen.
10. Beal, M. 1984. *A Study of Richard Symonds: His Italian Notebooks and Their Relevance to Seventeenth-Century Painting Techniques*. New York: Garland Publishing, fol. 46.
11. *Ibid.*, fol. 143.
12. *Ibid.*, fol. 75.
13. *Ibid.*, fol. 25.
14. Armenini, G. B. 1587. *De veri precetti de la pittura*. Ravenna.
15. A good example can be found in Caravaggio's *Boy with Lizard*. National Gallery, London.
16. Symonds in Beal, op. cit., fol. 10. “Terra Rossa, biacca da corpo a little. Creta un tantino, negro Carbone. He complayned the ordinary imprimers putt in no biacca.”
17. *Ibid.*
18. *Ibid.*

19. White, R. Personal communication. National Gallery, London. I am indebted to Raymond White for much enlightening discussion around the subject.
20. Symonds, op.cit., fol. 10. "To make imprimatura wich shall stand abroad in ye ayre, tis best to use olio Cotto. Also tis good dare una mano di gesso prima / poi oglio suopra."
21. Groen, K. 1988. Scanning electron microscopy as an aid in the study of blanching. *Hamilton Kerr Institute Bulletin* 1:48–65.
22. Burnstock, A. An examination of blanching in the green paints from a selection of seventeenth-century French School paintings. Ph.D. diss. Courtauld Institute of Art, London.
23. Groen, op. cit.
24. Lebrun, P. 1635. Recueil des essaies des merveilles de la peinture. In Merrifield, M. P. 1849. *Original Treatises on the Arts of Painting*. Vol. II. London: John Murray, 759–841. On page 821: "To prime a canvas quickly, so that a person may paint on it the same day that it has been primed, you must grind together some parchment glue and oil priming, and immediately prime the canvas with this; it will harden directly, but the priming is apt to scale off when the canvas is rolled up."
25. Malvasia. 1646. Vite di Pittori Bolognesi. Unpublished addenda. In *Scelte di curiosità letterarie, inedite o rare dal XIII al XIX*, ed. Adriana Arfelli. Speaking of Guercino's *Circumcision in the Chiesa delle Monache di Gesù Maria* in Bologna which was executed overnight: "La sua formidabil velocità nell'operare, e alla prima bozzando, e finendo nello stesso tempo."
26. For instance, Caravaggio's *Salome with the Head of St. John the Baptist* (National Gallery London) and Mattia Pretis's *The Beheading of St. John the Baptist* (National Gallery of Ireland, Dublin).
27. Félibien, op. cit., Entretien VIII, 401. "[L]a diminution des teintes . . . autant par la qualité que par la force des couleurs."
28. Either an optical effect due to the pronounced lithargeage of the ground or the inherent matte appearance of the varnish itself.
29. Boschini, op. cit., 295. "Credela che se goda la Pitura / Più soto l'ochio, o in debita distanza? / Certo in distanza debita: perché / Quando havè messi i quadri, e situdi / In l'altezza de iluoghi destinadi, / Non è rason, che là ve rampegghè."
30. This was the case during the examination of Gainsborough's *The Linley Sisters* in the Dulwich Picture Gallery. Gainsborough had painted the portrait with the light coming from the left through holes he had drilled in his shutters! See Glanville, H. 1988. Gainsborough: Artist or Artisan? (original unedited version). In *A Nest of Nightingales*, s.l. exhibition catalogue.
31. Biography of Ludovico Cardi, in Cardi, G. B. 1628. *Il Cigoli*. Florence, 19. "[M]olto più ammirabil si rendeva in quella stanza dove fu lavorata, la qual per una picciol finestra ricevendo poco lume era appunto proporzionato et alla maniera et a quello che nella storia si rappresentava; et avendola ivi veduta più volte, e, rivedendola poi all'aria aperta, diceva fra sè: questa non è quella, sebbene quivi ancora lodata da tutti."
32. Bellori, op. cit. Vita di Luca Giordano, 51. "[E]ssendo il tutto condotto con grossi trattizzi ne' contorni, e così anche il Cristo, benchè sia alquanto più terminato, come figura principale del soggetto, nel cui panno azzurro si veggono chiari terribili di biacca imbrattata di carnatura, con tratti di pennello più grossi, il quale unisce ed accorda tanto bene con la distanza dell'occhio, che fa comprendere quanto sia grande la maestria del suo pennello."
33. Boschini, op. cit., 339. "[L]a prontezza . . . impastar figure in copia, e senza natural. . . ."
34. Boschini, op. cit., 339. "L'è quel unir quel fresco con quel seco / Che in sto operar si belo importa tanto."
35. Boschini, op. cit., 294. "Perchè se se vardasse al color solo, / El più vago sarave anche il più belo / Ma varvandose el trato del penelo / Casca sta consequentia a rompicolo."
36. Boschini, op. cit., 290. "[L]'occhio no'vede altro, che'l guanto."

Abstract

French publications on painting materials and techniques before 1800 include books of “secrets,” treatises written by artists themselves or about their practice, articles from learned journals, dictionaries, and encyclopedias. The traditional methods of painting listed in these publications include *détrempe* (a reference to a water-based media, which can be glue, gum, or egg tempera), fresco, miniature, and oil painting, enamel and glass painting, as well as painting on porcelain. Some of the more unusual techniques are outlined: encaustic, *eludoric*, and glass painting, including glass transfer techniques, and finally a satirical contribution, “peinture en fromage ou en ramequin.”

From Books of Secrets to Encyclopedias: Painting Techniques in France between 1600 and 1800

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Introduction

Until the mid-seventeenth century, the business of painting in France was strictly regulated by guilds. The skills of the painting craft, handed down from master to apprentice, were treated as valuable personal possessions and protected by secrecy (1). Few records of the painting techniques themselves were published before the mid-eighteenth century. The first information contributing to the history of painting materials and techniques in the French language is found in books of “secrets,” collections of recipes on various topics, often compiled from diverse authors. The “secrets” of the earliest such books were not contemporary recipes, however, but translations from Italian or Latin, often with reference to ancient Greek or Roman authors.

Books of secrets

The first of the books of “secrets,” *Les secrets de reverend Alexis Piemontois* (Paris, 1557) was a compilation, translated from the Italian, that included remedies for illness, wounds, and accidents, as well as instructions on how to make perfumes, jams, dyes, and pigments. The book was reprinted in 1573 and was expanded to include recipes from Dioscorides, Galen, and others, as well as some recipes relating to the history of painting techniques such as gilding, pigments, inks, and the making of varnishes. It was republished several times during the sixteenth and seventeenth centuries, as were other secret books, such as *Les secrets et merveilles de nature* (Lyon, 1586) by Jean Jacques Wecker, a doctor from Colmar. Wecker’s recipes for magic and sorcery, health, cooking, beauty, and the manufacture of pigments, “des secrets des falseurs et vendeurs de couleurs et peintures,” were also taken from Latin sources; he credits seventy-five authors from Aristotle onward. Fortunately, the book includes a table of contents, for the recipes are not arranged alphabetically but in a systematic order that reflects Wecker’s vision of the universe and places painter’s secrets on the same level as recipes for cooks, druggists, carpenters, and joiners.

Several books of secrets were published in the seventeenth century, but perhaps the most popular and the most relevant to our topic was Le Sieur D’Emery’s *Recueil des curiositez rares et nouvelles des plus admirables effets de la nature [et de l’art]* (Paris, 1674) (2). Included were many recipes related to the history of painting techniques, recipes on how to copy drawings, make pastels, imitate marble, stain wood, gild, and make engravings look like old master paintings.

Books of secrets continued to be written and reprinted throughout the eighteenth century and beyond. In the eighteenth century, the two compilations most frequently reissued were *Secrets des arts et métiers* (Brussels, 1755) and *L’Albert moderne ou nouveau secrets éprouvés et licites* (Paris, 1768). This “modern” Albert was a revision of “old” Albertus Magnus, with the superstitions and enchantments deleted, keeping only “useful” advice, such as how to cure a toothache with two live moles. (The method begins by holding a mole in each hand and squeezing gently, without letting go, until they die; this process should take about five hours.) Large sections are devoted to medical and agricultural recipes; the third section includes “divers moyens de se faire une

occupation agréable pour charmer l'ennui," with recipes about liqueurs, flowers, painting secrets, and so on.

Technical treatises

The most widely read of the early painting manuals, judging by the number of editions, was Claude Boutet's treatise on miniature painting, published in 1672, called by the author an "*ABC de la miniature*" (3). Following the conventions of his time, Boutet dedicated his treatise not to the specialist but to an amateur, a Mlle. Fouquet, who wished to perfect her abilities in the craft. In the introduction, Boutet claims his "secrets" came from the Italians, and states that although he could have profited by keeping them to himself, he is giving away his knowledge for the benefit of others. He provides an extremely useful summary of French painting practice in the second half of the seventeenth century. The treatise discusses the various pigments and how to use them, based on a three-step sequence (as in oil painting of the period): *ébaucher*, *pointiller*, and finally *finir* or *rehausser*.

A seventeenth-century treatise of great importance for the history of technique is De La Fontaine's *Académie de la peinture* (Paris 1679), dedicated to the tutor of the future king of France (4). He summarizes much practical detail, especially on pigment mixtures, mentioning *détrempe*, fresco, pastel, *grisaille*, and miniature as well as oil painting. He refers to the art of perspective, which he believes a painter should know both theoretically and practically. His dependence on Italian painting is evident, and he lists the names of the Antique painters who have contributed to this knowledge (5). He also discusses the origin of painting; although several "philosophers" attributed the origin of painting to a shepherd who began to trace his shadow and saw the resemblance to the human form, De La Fontaine allows that the more common opinion is that the discovery of painting was made by the Hebrews and that they transmitted it to the Greeks and to the Romans. Until the late eighteenth century, it was believed that this knowledge was then "lost," to be "rediscovered" by "Jean de Bruges" (Jan van Eyck).

Seventeenth-century painters thus considered oil painting a "new" method of painting, and, judging from the source books, the preparation of the medium was obviously a vexing problem. De La Fontaine suggests nut oil with lead white thickened by sunlight (6). He follows this with the recommendation that in order to dry a layer of lead white, or a *grisaille* layer, one should mix the white pigment with oil of turpentine, which will cause the layer to dry as the turpentine evaporates (7). This is followed by advice on how to prevent layers of drapery from running. He suggests placing the painting flat on the floor or on a table and scattering small pieces of absorbent paper onto the surface, especially onto the shadows of the drapery. When the paper has drawn out the oil, but before the paint layer has dried, one should pick up the painting and let it fall gently on one corner, so that the paper comes away (8).

Although it is not possible to go into detail about early technical practice here, I will mention briefly De La Fontaine's method of preparing supports for painting, methods used well into the eighteenth century. In the case of canvas, the material was stretched onto a loom, smoothed with a pumice stone, sized with glue, and then given a double ground, the first colored with raw umber and red brown spread on with a knife, the second with lead white and just enough carbon black to make gray. For panels, three layers of a fine chalk ground ("blanc d'Espagne, comme on le vend chez les Chandeliers") was recommended, with either another layer of glue on top or a gray oil layer (9).

The Académie Royale and the theoretical treatises

Before 1800 the history of oil painting in France, and consequently the history of its technique, was dominated by Italian influence. In the sixteenth

century, the royal patronage for the School of Fontainebleau was crucial. Later, most ambitious French painters traveled to Italy, often spending much of their professional lives there. The influence of the French Academy, the Académie Royale de Peinture et de Sculpture founded in 1648, was also of central importance for any aspect of the history of painting in France. By 1655 it had become a royal enterprise and was soon the most powerful art institution in Europe. The purpose of the Academy was to convey the principles of art to its members by means of lectures and to instruct students through life classes. In 1673 the Academy also began organizing exhibitions for its members. These exhibitions were not opened to a wider public until 1791 (10).

With the noble aim of nurturing good craftsmanship, the Academy defined the principles from which painters were not allowed to deviate. The goal was to train students in one particular style of drawing. The necessity of copying from the ancients was stressed, and this emphasis continued until the French Revolution. Nowhere outside the Academy was a life class allowed, even in an artist's private studio. The Academy did not provide for the whole of the professional education of a young painter, however; the student painter still learned the basics of his craft in the workshop of his master, in whose house he often lived, just as in the Middle Ages. Thus, craft "secrets" were still essential to a painter's success, and only gradually were detailed accounts of methods and materials forced into print. The publication of Diderot's encyclopedia in the mid-eighteenth century and the French Revolution a few years later provide evidence of the culmination of a trend toward the dissemination of knowledge which had proved impossible to stem.

The personalities of Jean-Baptiste Colbert (1619–1683), the elected "Protector" of the Academy, and Charles LeBrun (1619–1690), "Premier Peintre du Roi," were crucial in the development of the Academy and thus to the history of French painting. Since it was a royal academy, the king's (i.e., Colbert's) intentions were imposed, and Colbert's tight dictatorship led to a centralization from which France has still not fully emerged. The approval of the Royal Academy was a necessity for every endeavor within its sphere of influence. Colbert was also responsible for the creation of many other academies in addition to the Académie de la Peinture, including the Académie des Sciences in 1666; the importance of this fact to the subject will be indicated later.

The lectures of the Royal Academy were the basis for many of the published treatises of the seventeenth and even the eighteenth centuries. Aesthetics, beauty and proportion, lighting and perspective, and the expressions of the figures portrayed were discussed at length by seventeenth-century authors. Charles LeBrun's famous lectures on human expression (1668) influenced generations of artists. Most of the academic authors, such as Roland Fréart de Chambray, André Félibien, Charles Alphonse Du Fresnoy, and Roger De Piles, were not professional painters, however, and were more concerned with theory than practice. The dispute between the Ancients (Poussinistes) and the Moderns (Rubenistes) dominated the Academy lectures for more than twenty years. The study of the lives of ancient Greek and Roman as well as Renaissance painters was also a popular subject, as was the history of the origin and "rediscovery" of painting. Although the academic lectures did not usually discuss techniques, Jean Baptiste Oudry's (1686–1755) lectures were an important exception. As president of the Academy, Oudry gave a lecture in 1752 on painting techniques as practiced by the members (11).

The spokesman of the Poussinistes, Roger De Piles (1635–1709), an amateur painter, connoisseur, and member of the Academy, was a prolific writer on the theory of painting. He did, however, compose one book on technique in 1684, *Les premiers élémens de la peinture pratique*. As edited and augmented by Charles Antoine Jombert in 1776, the text became the most important and informative collection of recipes on French painting technique of the seventeenth and early eighteenth centuries (Figs. 1, 2). Another important author for the history of technique was Philippe de La Hire of the Académie Royale

ÉLÉMENTS

DE

PEINTURE PRATIQUE.

Par M. DE PILES, de l'Académie Royale de Peinture & Sculpture.

NOUVELLE ÉDITION

Entièrement refondue, & augmentée considérablement.

Par CHARLES-ANTOINE JOMBERT.



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M. D C C. L X V I.

T A B L E

DES CHAPITRES

contenus dans cet ouvrage.

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Figure 1. From Roger De Piles, *Elémens de peinture pratique*, 1766. Paris: Charles-Antoine Jombert. Roger De Piles was an amateur painter and a prolific writer on the arts. The information in Jombert's edition was intended to instruct those who desired counsel on how to paint and provided explicit instructions on all aspects of the profession.

des Sciences. His *Traité de la pratique de la peinture*, published in 1730, concerned painting as it was practiced from the late seventeenth century to 1730. He gives advice on drawing, oil, tempera and miniature painting, fresco, mosaic painting, enamel painting, painting on glass, pigments, and tools for painting. A three-step method of painting, “ébaucher, empâter, retoucher” is taken for granted. Like De La Fontaine, he recommends preparing canvas with a double ground, but gives much more detail. On the preparation of canvas, he admits that some painters use only the first red ground because the colors sink less: These canvases “font moins mourir les couleurs” and are more easily rolled. Other painters preferred using canvas with a white glue ground for oil paint, which, he adds, appeared to work well.

The difficulties of this “new” oil medium continued to trouble La Hire, however, especially the problem of the sinking of the paint layer, particularly in dark colors. He disapproved of those painters who did not apply sufficient layers of paint, finishing with what he considered only an *ébauche* (sketch), using little pigment and lots of oil, as if painting a glaze. If there was not sufficient paint in the upper layers, he warned, the top paint layer would sink into the layer underneath, a process he called *emboire*. Emboire was caused by painting on a ground that had not dried sufficiently, or painting on a still-wet paint layer, or using excessive oil, especially oil of turpentine. If the paint

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Figure 2. From Roger De Piles, *Elémens de peinture pratique*, 1766. Paris: Charles-Antoine Jombert.

did sink, however, he suggested applying with a small sponge a layer of nut oil mixed with a siccative before continuing to paint. He added that although this layer should dry before adding further details, it was possible to paint fine lines of architectural elements while the layer is still wet (12).

Learned journals and periodicals

Colbert's establishment of the Académie Royale des Sciences in 1666 stimulated the growing interest in technology, and consequently publications of new scientific discoveries increased in number.

The prodigious growth of the dyeing and textile industries in the eighteenth century was a contributing influence. Porcelain manufacture, too, was indirectly responsible for many publications concerning materials, especially pigments, that could be used for painting. The diffusion of this material was sometimes effected through official publications such as the *Imprimerie Royale* or Royal Academy of Science's *Descriptions des arts et métiers* (13). A few articles of interest were even privately published (14). From 1737, Salon exhibitions of the Academy began to be reviewed by newspapers such as *Mercur de France*; these reviews sometimes included technical information.

The *Journal des Sçavans* was a fundamental journal for the dissemination of scientific information in the seventeenth and eighteenth centuries, appearing from 1665 until 1825, with a few lapses in publishing. Information relevant to the history of painting techniques was often included; the treatises by Antoine Raphael Mengs and Gerard de Laresse, for example, were discussed at length (15).

By the mid-eighteenth century there were many periodicals in which articles on painting materials or techniques could be found: *Observations périodiques sur la physique, et les beaux-arts*, *Annales de chimie*, the *Bibliothèque physio-economique, instructive et amusante*, the *Magasin encyclopedique*, and the *Journal des Sciences*, to mention a few of the most important periodicals (16). The increased economic interaction between France and England in the later half of the eighteenth century is reflected in articles in the *Journal Oeconomique* (17). Many articles in these French journals were translated from English publications, including those of the royal societies in London. In fact, the flow of information had increased all over Europe (18).

Dictionaries and encyclopedias

The increasing number of publications in France in the eighteenth century reflects the general opening up of society in France. An important step forward in the dissemination of craft "secrets" was the publication of Diderot's encyclopedia. During the period from 1751 to 1772 the *Encyclopédie ou Dictionnaire raisonné des sciences, des arts, et des métiers* first appeared in thirty-nine volumes edited by Denis Diderot (1713–1784) and Jean le Rond d'Alembert (Figs. 3, 4) (19). It was a heroic task with articles by 160-odd contributors and 2,885 plates. Diderot's encyclopedia was a landmark in the recording of knowledge, and remains one of the greatest literary enterprises in human history.

There were precedents for the *Encyclopédie* of course, although the early dictionaries were much smaller, usually two volumes. In the field of the arts, the important sources were Thomas Corneille, *Dictionnaire des Arts et Sciences* (Paris 1694); Antoine Furetière, *Dictionnaire universels* (The Hague-Rotterdam 1690); and the *Dictionnaire de Trevoux* issued by the Jesuits (Aix 1704). These sources were pillaged by Diderot, following the usual practice of the time (20). While Diderot's encyclopedia was for the enlightened rather than the multitude, other authors tried to make the information more accessible. Both Lacombe (1752) and Macquer (1766) wrote "portable" dictionaries, as did many others (21). In the preface to his *Dictionnaire portatif de peinture, sculpture et gravure* (Paris 1757), Pernety even apologized for producing yet another dictionary. He wrote (22):

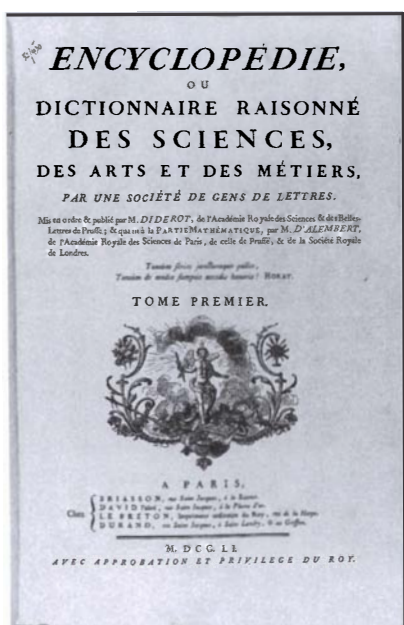


Figure 3. From *Encyclopédie ou dictionnaire raisonné des sciences, des arts, et des métiers*. 1751–1772. Eds. D. Diderot and J. le Rond d'Alembert. Paris.

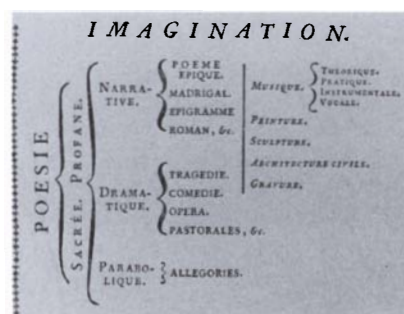


Figure 4. From *Encyclopédie ou dictionnaire raisonné des sciences, des arts, et des métiers*. 1751–1772. Eds. D. Diderot and J. le Rond d'Alembert. Paris.

In spite of the laments of certain people who complain of the taste of the century for dictionaries, this predilection is increasing, a proof of the benefit the public is receiving. We are inundated, and if this torrent is not stopped, we will be learning only from dictionaries. . . . We want to know everything—or rather speak of every thing and pretend to be ignorant of nothing. We must submit, therefore, to this “goût du siècle.”

Encaustic painting

The history of oil painting was an eighteenth-century fascination. In the mid-eighteenth century Diderot still believed, as De La Fontaine previously asserted in his seventeenth-century treatise, that the art of painting was reborn when “Jean de Bruges” (Jan van Eyck) discovered the “secret” of oil painting. It was generally accepted that the Ancient painters possessed superior techniques, and that it should be possible to “rediscover” their methods. By the eighteenth century there was also concern about the state of seventeenth-century paintings, which no longer retained the freshness of those more recently painted (23).

The experiments of the Count of Caylus and his search for the Ancients’ “lost” painting media that did not discolor, flake, or deteriorate are well known, possibly because Caylus himself published a memoir on the subject in 1755 (24). Diderot and the painter Bachelier were also interested in the experiments with encaustic or colored wax.

The method, which required a hot plate to fuse the final composition, had many variations; some involved impregnating a gouache painting with a layer of wax, while other methods used colored waxes (Figs. 5, 6) (25). By 1770, M. Charles Baron de Taubenhien was convinced he had succeeded where the Count had failed. Joseph Fratrel published this method in *La cire alliée avec l’huile ou la peinture à huile-cire*, and offered a free sample to any recognized painting academy (26).



Figure 5. Frontispiece and title page from Caylus and Majault’s *Mémoire sur la peinture à l’encaustique et sur la peinture à la cire*. 1775. Geneva and Paris.

Eludoric painting

Another painter concerned about the deterioration of oil paintings was Vincent de Montpetit, a painter of miniatures who invented eludoric painting in 1775 as a permanent form of painting. The name of the technique was de-

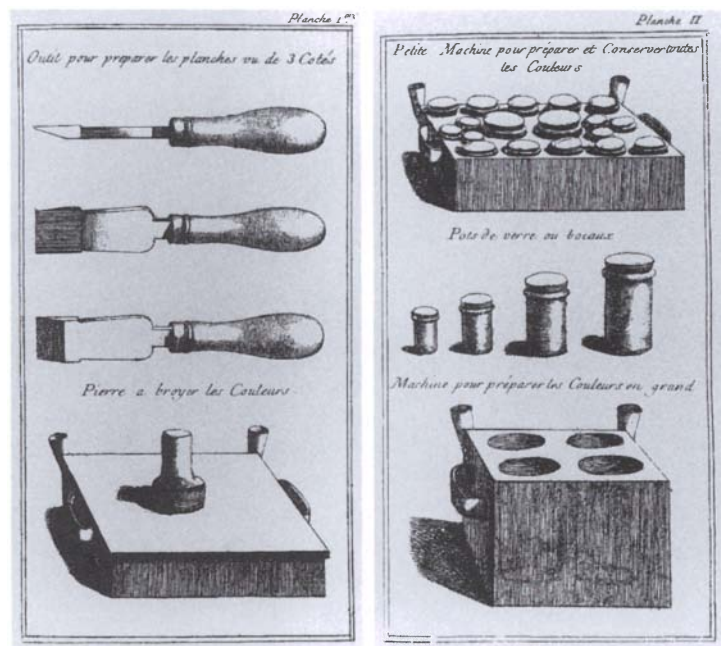


Figure 6. Plates 1 and 2 from Caylus and Majault’s *Mémoire sur la peinture à l’encaustique et sur la peinture à la cire*. 1775. Geneva and Paris.

rived from the Greek words for oil and water, the two main components of the method. The method follows (27):

The support, usually of fine cloth primed with poppy oil, is placed under a thin film of water and all painting done in oil under water. The water, because of its transparency, acts as a crystal, allowing the painter to judge the quality of the brush strokes, add fine detail and see the darks without having to oil out or use a retouching varnish to resaturate the surface. The painting could be retouched and reworked as often as required without leaving the paint surface thick and shiny since a skin was not formed; all excess oil floated off in the water. The only oil retained was the amount necessary to adhere the pigment to the support. While painting, the artist saw his work exactly as it would be when behind glass. Thus, in theory, the painting did not contain too much oil and not being varnished or exposed to the air, the two main causes of the deterioration of paintings, according to Montpetit the inventor of the method, no degradation was to be feared.

Eludoric painting was favored in the eighteenth century, especially by the Court, and was mentioned in publications with the same frequency as encaustic or enamel painting. By the nineteenth century, however, it was mentioned only infrequently and by the twentieth century, the technique was practically forgotten.

Glass and glass transfer

Not only was there a desire to improve upon the old techniques, but new methods of painting were developed to satisfy the increasing number of amateur painters, as well as the skilled craftsmen who wished to imitate oil paintings by using easier methods. It had also become necessary to accommodate a growing demand by the bourgeoisie for oil paintings, or imitations of oil paintings, to decorate their walls.

The more commonly known method of painting on a piece of glass in reverse (i.e., the details first) was adopted because no knowledge of draughtsmanship was required in *Le moyen de devenir peintre en trois heures, et d'exécuter au pinceau les ouvrages des plus grands maîtres sans avoir appris le dessin* (Paris 1755). This simple method allows one to learn the art of painting without having to learn to draw (28):

A mezzotint print is laid onto glass with an adhesive which does not dissolve in water. The texture of the paper was destroyed by water so that the paper could be rubbed off leaving the ink of the print upon the cement and glass, as if the original impression had been made on the glass. The inked outlines could then be coloured with oil varnish or water colours and the result framed to resemble an oil painting.

An eighteenth-century French satire

The many experiments to find the ideal painting medium or the ideal painting method resulted in a profusion of new techniques in mid-eighteenth-century France. The humorous side of these many and varied “discoveries” was not lost on the public. The year the Count of Caylus published his “new” method of painting with wax, Montpetit invented eludoric painting, *Le moyen de devenir peintre en trois heures* appeared, Jean André Rouquet countered with yet another new technique: the art of painting in cheese. In 1755 his satirical brochure, *L'art de la peinture en fromage ou en ramequin* was prefaced with the history of this technique of painting in cheese (29). Rouquet lamented that many trials were necessary before succeeding with his experiment, thus requiring him to purchase many cheeses. He had, as he tells it, almost decided to give up and eat his cheese, when he made his “discovery.” Like Diderot and Caylus and others before him, he could not claim the discovery for himself, but credited the ancient Greek painters with the initial invention:

While cooking their eggs, two young Spartans quarreled over a piece of cheese which had just disappeared in the frying pan. Both young men armed themselves with a spoon and searched the scrambled eggs, but in vain. The cheese was gone. They came to blows, one claiming the cheese was still there, the other that it had disappeared, carried off by a genie. The noise of this battle drew a crowd, and the cause of the dispute became known. It was suggested that the experience be repeated. The ability of egg yolk to dissolve cheese was recognized.

The author consoled himself that he was not the first to have discovered this secret, and so made it public, congratulating himself on his generosity. Others might have kept the critical ingredient secret in an attempt to profit from it. Selling his secret would have been understandable, after all, as reimbursement for the heavy expenses in eggs and cheese. Rouquet continues his description with all the seriousness of a technical treatise:

Mix gruyere cheese cut in fine strips with two beaten egg yolks over a bain-marie until the cheese has melted. For the question of a support for the painting—since cheese does not adhere well to panel or canvas, it is better to follow its natural association with bread. Therefore, take flour and make dough with a little milk. Finally, it would be beneficial to add a bitter substance to discourage worms, mice, and children from eating the paintings. However, by leaving it out, poor painters could at least dine on their own paintings.

Conclusion

As we approach the twenty-first century, our curiosity increases about how paintings of past generations were created. More and more, we look toward modern methods of scientific analysis to answer our questions about historical painting materials, but a return to the written sources on painting techniques is an important first step toward a proper understanding. By definition, painters are practically oriented, however, and have rarely composed with the pen as well as the brush; records of their materials and techniques must be plucked from various publications. Undoubtedly during the coming decades, historians of painting technique will be recovering more information from the source books about the history of studio practice, painting materials, and techniques.

Notes

1. Patent rights existed in Europe in the mid-eighteenth century, but enforcement came only much later; in order to benefit from a discovery, the inventor still relied on secrecy. Singer gives an example involving an improvement to the system of production of liquid bleach made in 1789 for which the patent owner enjoyed the protection of his patent for only four years. Singer, C., et al. 1958. *A history of technology* (4): Oxford, 247.
2. A book of secrets, *Essay des merveilles de nature et des plus nobles entifces* (Rouen, 1622), proved so popular that by 1657, it was already in the thirteenth edition. The author was Etienne Binet, the pseudonym of René François, Prédicateur du Roy.
3. Boutet, C. 1672. *Traité de la mignature, pour apprendre aisément à peindre sans maître, et le secret de faire les plus belles couleurs, l'or bruny, et l'or en coquille*, Paris. Other editions were published with slight variations in the title and contents. Some editions appeared anonymously as *Escole de la mignature*. At least twenty-five editions were published between 1674 and 1800.
4. De La Fontaine. 1679. *L'Academie de la peinture* [etc.], Paris. De La Fontaine dedicates his treatise to “Mesire Charles de Sainte Maure, . . . Gouverneur de Monseigneur le Dauphin,” for the education of the future king. Two other important treatises of the seventeenth century are now available in facsimile editions. These are Bernard Dupuy du Grez’s 1699 *Traité sur la peinture pour en apprendre la theorie, & se perfectionner dans la pratique*, Toulouse: J & A. Pech; and Le Blond de la Tour’s 1669 *Lettre à un de ses amis, contenant quelques instructions touchant la peinture*. Bourges et Bordeaux. By the eighteenth century, the number of treatises

- increased considerably; the reader is best referred to Massing's 1990 bibliography (available from the author).
5. De La Fontaine, op. cit., épître aiiii: "Je pretend les instruire [les jeunes] au mélange des couleurs, à la force des teintes, & à la union des jours & des ombres que les Romains nomment clair-obscur."
 6. De La Fontaine, op. cit., 15: "Autre huille grasse pour faire seicher les couleurs. Vous prendrés de l'huile de noix dedans une fiolle, vous y mettrés de la mine de plomb, & du blanc de plomb pillé ensemble, la mettrés au soleil, cela s'en-graisse, & sera fort clair: on en mesle avec des couleurs, quand on est pressé pour les faire."
 7. De La Fontaine, op. cit. "Beau secret pour faire seicher le blanc de plomb sans changer. Quand vous voudrés faire seicher du blanc de plomb, couche entiere, ou bien avec du gris, en grisaille, vous prendrés de l'huile de terebentine meslée avec vostre blanc, il le fera seicher: notés que l'huile de terebentine fait tout seicher, *parcequ'elles'en va en fumée.*" [Author's emphasis.]
 8. De La Fontaine, op. cit., 17.
 9. De La Fontaine, op. cit., 27–28. For the preparation of a copper plate: "L'on prend une plantaine de cuivre bien poly, après vous prendrez du blanc de plomb bien broyé avec de la terre d'ombre, & noir de charbon meslé ensemble, avec une brosse vous frotterez par dessus la plataine bien unie, & avec un linge & du cotton dedans vous frapperez dessus, pour la rendre mieux unie, quand la couleur sera seiche vous prendrez un cousteau & passerez par dessus pour unir davantage, apres vous la chargerez encore une fois, & ferez encore de mesme; le laissant seicher, vous pouvez travailler après pour peindre sur une pierre ou plastre. . . ."
 10. The history of the French Academy has been written by several authors. See Pevsner, N. 1940. *Academies of Art Past and Present*. Cambridge; and more recently, *Tradition and Revolution in French Art 1700–1880*. 1993. London: National Gallery.
 11. Oudry. 1753. *Discours sur la pratique de la peinture et ses procédés principaux: ébaucher, peindre à fond, et retoucher*. Paper presented to the French Academy, 2 December 1753, published from the manuscript in the Ecole des Beaux-Arts. In *Le Cabinet de l'amateur, 1861–1862*. 1863. Ed. E. Piot. Paris, 107–17. For further discussion of Oudry's lecture, especially as it relates to his use of varnish, see Swicklik, M. 1993. French painting and the use of varnish, 1750–1900. In *Conservation Research*. Washington, D.C.: National Gallery of Art, 157–74.
 12. La Hire, Philippe de. 1730. *Traité de la pratique de la peinture*. Paris, 710–14.
 13. P.J. Macquer published several small brochures printed by the Imprimerie Royale containing information on pigments used both in the dyeing industry and for painting. In the series *Description des arts et metiers faites ou approuvées par Messieurs de l'Académie Royale des Sciences*, many articles were published which were publications in their own right; subjects include pigments used for dyeing, pigments for painting on porcelain, different types of glues, and the making of parchment.
 14. For example, a translation of a publication of the Royal Society of London on minerals by E. Hussey with reference to their use in painting was published by Dijonval. See Delaval. 1778. *Recherches expérimentales sur la cause des changemens de couleurs dans les corps opaques et naturellement colorés*. Translated from the English by Dijonval. Quatremère: Paris de l'imprimerie de Monsieur.
 15. Mengs, A.-R. 1786. *Oeuvres completes d'Antoine-Raphaël Mengs, premier peintre du roi d'Espagne, &c. Contenant différens, traités sur la théorie de la peinture. Traduit de l'italien*. Vols. I–II. Paris. Mengs wrote various treatises on the theory of art. See also Lairesse, Gérard de. 1787. *Le grand livre des peintres, ou l'art de la peinture considéré dans toutes ses parties, et démontré par principes; avec des reflexions sur les ouvrages de quelques bons maîtres, et sur les défauts qui s'y trouvent. Auquel on a joint les principes du dessin du même auteur. Traduit du Hollandois sur la seconde édition*. Vols. I–II: Paris. (Dutch original: *Groot Schilderboek*. Haarlem. 1740). Lairesse was considered among the best painters of his time. His treatise was well known to eighteenth-century writers and artists, and his work is representative of practice in the early eighteenth century. Book IV is entirely devoted to colors and coloring; there are also chapters on drawing, composition, portraits, ceiling painting, engraving, etc.
 16. *Observations périodiques sur la physique, et les beaux-arts* continued from 1756 to 1823, although the title changed to *Journal de Physique et chemie d'histoire naturelle et des arts*.
 17. In the *Journal Oeconomique*, 1751–1772, in addition to various articles of interest, the tables of merchandise arriving into the ports of London, Amsterdam, etc., were published, with prices and exchange rates for various materials including

- some used for painting (i.e., amber, brazilwood and cochineal, gum arabic, indigo, saffron, sandarac, shellac, verdigris, vermilion, etc.).
18. The Royal Academy in London was founded in 1768. By that period, the exchange of information all over Europe was so rapid that translations of new methods and techniques happened very quickly. See also Carlyle, L. 1991. A critical analysis of artists' handbooks, manuals and treatises on oil painting published in Britain between 1800–1900: with reference to selected eighteenth-century sources. Ph.D. diss. Courtauld Institute of Art, University of London. Also, compare early German source books, including Schiessl, U. 1989. *Die deutschsprachige Literatur zu Werkstoffen und Techniken der Malerei von 1530 bis ca. 1950*. Worms.
 19. The layout of Diderot's great work is not alphabetical but systematic, after the division of the sciences following the scheme of Francis Bacon (1561–1626) for an *Encyclopaedia of Nature and Art*, which was published in 1620 (the encyclopedia itself was never published). Painting is listed under two categories: philosophy and imagination. Alphabetical arrangement of the contents of an encyclopedia came into general use in the eighteenth century, and indexing was not employed until the 1830s. For further information of the dramatic history of Diderot's encyclopedia, see Collison, R. 1964. *Encyclopaedias: Their History throughout the Ages*. London.
 20. Copying from previous authors was commonplace in the seventeenth and eighteenth centuries; everyone did it, and it was unusual when a source was cited. One splendid example is the recipe for making drying oil by boiling nut oil with litharge, water, and one onion. None of the authors really believed in the efficacy of the onion, but dutifully copied it nonetheless. See Pernety, D. A.,-J. 1757. *Dictionnaire portatif de peinture, sculpture et gravure*. Paris, lxxxvii–lxxxviii. Pernety copied the recipe from La Hire (La Hire, op. cit., 708): “Il y en a qui font cuire avec l'huile un oignon coupé en plusieurs morceaux pour la dégraisser & pour la rendre plus coulante & moins gluante, à ce qu'ils prétendent.” De Piles copied it again with similar doubts and suggested using a piece of bread instead (De Piles. 1776. *Elémens de peinture pratique*. Charles-Antoine Jombert, 141–42).
 21. Lacombe, J. 1752. *Dictionnaire portatif des beaux-arts*. Paris. See also Macquer, P. J. 1766–1767. *Dictionnaire portatif des arts et métiers*. Paris. For information on the many dictionaries published in the later half of the eighteenth century, see Massing's 1990 bibliography (available from the author).
 22. Pernety, op. cit. (note 20), iii–iv.
 23. Several authors refer to the imperfections of the oil medium. De Piles. 1766, op. cit. (note 20), 97–98. De Piles writes of the deterioration of oil painting, “Cette espece de peinture est moderne en comparaison des autres. . . . Il n'y a pas de doute qu'elle seroit la plus parfaite de toutes les manieres de peindre, si les couleurs ne se ternissoient point par la suite des tems; mais elles brunissent toujours de plus en plus & tirent sur un jaune brun, ce qui vient de l'huile avec laquelle toutes les couleurs sont broyées & incorporées.”
 24. Caylus, M. le Comte de, and M. Majault. 1755. *Mémoire sur la peinture à l'encaustique et sur la peinture à la cire*. Geneva and Paris.
 25. Eighteenth-century authors such as the Count of Caylus believed that the Ancient Greek painters used an encaustic painting technique. The wax was “fixed” to the wooden support by placing the completed painting next to an open fire. Since the only painting materials Pliny mentioned were wax, pigments, fire, and brushes, Caylus dismissed the use of solvents such as turpentine to soften wax and make it “paintable.” To paint as the ancients did, Caylus considered that the wax needed to be heated. The watertight metal boxes depicted here could be filled with boiling water, which kept the colored waxes at a constant temperature. The box on the left has a roughened glass top used to grind the colors. A similar box with an opaque top would be a palette.
 26. Fratrel, J. 1770. *La cire alliée avec l'huile ou la peinture a huile-cire. Trowée à Manheim par M. Charles Baron de Taubenheim expérimentée décrite & dédiée à l'electeur*. Manheim.
 27. For further discussion of this method of painting, which was taken quite seriously not only by the inventor himself, but by most contemporary source books, see Massing, A. 1993. Arnaud Vincent de Montpetit and eludoric painting. *Zeitschrift für Kunsttechnologie* 7 (2):359–68.
 28. For a discussion of this popular technique, see Massing A. 1989. From print to painting. The technique of glass transfer painting. *Print Quarterly* 6 (4):382–93.
 29. Rouquet, J. A. 1755. *L'art nouveau de la peinture en fromage, ou en remequin, inventée pour suivre le louable projet de trouver graduellement des façons de peindre inférieures à celles qui existent*. Marolles.

Abstract

The Roberson Archive, the archive of the artists' colorman Charles Roberson & Co. (1819–1985) is housed at the Hamilton Kerr Institute in Cambridge. Roberson was one of the most important colormen in nineteenth-century London. The material in the archive gives detailed information about the internal workings of the company and its relations to both its customers and suppliers. It is the largest artists' colorman archive in the United Kingdom and covers the period from 1815 to 1944, providing a record of the materials and techniques of many of the leading nineteenth- and twentieth-century British artists. In addition to catalogues, sample books, and more than three hundred account ledgers, there is a collection of pigments and objects sold by Roberson that provides material for analysis and study. A three-year research project is currently being undertaken to catalogue the archive, compile a database of the most important documents, and make the archive accessible for research.



Figure 1. Roberson's shop at 154 Piccadilly, ca. 1890–1911. Fitzwilliam Museum, University of Cambridge.

The Roberson Archive: Content and Significance

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The company's history

Charles Roberson opened his first recorded shop to sell artists' materials at 54 Long Acre, London. Although accounts of the firm's history give the date as 1810, Henry Matley is listed as "colourman to artists" at this address in a trade directory of 1817, and a note in a recipe book dating from around the turn of the century states that Roberson did not succeed Matley until 1819 (1). At that time, the shop was in the heart of the artistic area of London, with the Royal Academy Schools being based nearby in Somerset House on the Strand. In 1828 Roberson and his assistant Thomas Miller became partners and moved to 51 Long Acre (2). The partnership dissolved in 1840.

The company continued to trade on Long Acre, moving to the premises they built at number 99 in 1853. In 1868 the Royal Academy Schools moved to Burlington House, Piccadilly, and Roberson opened a retail branch on Piccadilly in 1890 (Fig. 1) (3). Over the following years, however, many artisans and manufacturing trades moved away from the center of London to be replaced by retailers and offices; in 1937 Roberson closed both the Piccadilly and Long Acre branches, moving to Parkway, Camden (4). They retained a West End presence for an unspecified length of time, arranging with the Medici Galleries in Grafton Street to move a "representative stock of Artists materials" from their closed Piccadilly branch in January 1940, to be sold from the galleries on commission (5). Two successive French addresses appeared in their catalogues after 1870, which they described as their *depôts* in Paris, but which were in fact the premises of Parisian colormen (6).

The company remained in the Roberson family until sold to a Dutch firm in the 1970s. G. F. Roberson Park remained a board member (7). In 1985 it went into liquidation. At liquidation the name was bought by the London colorman Cornelissen and a small range of high-quality materials bearing the Roberson name is still produced (8).

The arrival of the archive at the Hamilton Kerr Institute

In 1975 Roberson's historic accounts ledgers were moved to the Hamilton Kerr Institute (9). They were loaned to the Institute for safekeeping and research and, when the company was dissolved, became part of the Fitzwilliam Museum's manuscript collection. The archive is now housed in the Institute and will be available for research once cataloguing is complete.

The archive consists of a collection of objects, including a large number of pigment samples, and more than three hundred ledgers dating from 1815 to 1944. There are several continuous series of different types of ledgers, but there are many gaps, and some sets appear to be incomplete (10). Despite this, it is the most extensive artists' colorman archive in the United Kingdom. The manuscripts in the Roberson Archive give a detailed picture of the company's activities. Only the most important categories are discussed here, as many of the warehouse, order, day, and sundries books contain information duplicated in the main accounts books.

Catalogues and sample books

The catalogues preserved in the archive date from 1840–1853 to 1926–1933 and illustrate goods sold by Roberson. They offered a fairly conventional

range of artists' materials, books on art, and plaster casts of antique statues. Although they sold some patented equipment (such as a sketching stool that converted to a walking stick and the "Eiffel," a stool made of steel), Roberson avoided the more innovative artists' equipment patented in the nineteenth century, such as easels that also served as bicycles or rowing machines (11).

Most products were sold under the Roberson name, although a few materials such as paper were usually identified by the name of the manufacturer. It is therefore difficult to establish which materials were made by Roberson and which brought in to be made up and labeled on the premises. It appears that the company prepared their own canvas throughout the company's history, a room used for this was still extant in the Parkway workshop until liquidation (12). They also mixed their own paints, buying pigments and other materials from wholesale suppliers, in common with most other artists' colormen, not manufacturing the raw pigments themselves. In general they only bought small quantities of prepared paints from other artists' colormen, sometimes as little as one tube or cake bought for a specific customer. However, the popularity of Roberson's Medium, used for oil painting, was such that both British and foreign colormen bought wholesale quantities of it from Roberson. After the First World War, when Roberson's business was beginning a gradual decline, trading practices began to change and by the period following the Second World War, a reciprocal arrangement with the London colorman Rowney was made to divide trade into two spheres, Roberson supplying Rowney with canvas and Rowney supplying Roberson with paints (13).

The catalogues indicate the cost of artists' materials and demonstrate prices were stable for much of the nineteenth century. There is a clear differentiation between luxurious pigments such as ultramarine or carmine and other, cheaper colors; the catalogues show that an ounce (28.35 g) of genuine ultramarine was twenty-eight times as expensive as its artificial substitute between around 1840 and 1911, with prices almost completely stable in that period. The catalogues also reflect the introduction of new pigments and demonstrate that there could be a considerable time lag between the discovery of a pigment and its commercial application. Roberson & Co. appears to have been comprised of rather reactionary colormen, who contributed little to technical innovation, emphasizing the hand-prepared nature of the company's products until long after many of the other colormen had introduced a degree of mechanization; their reaction to new developments, therefore, may not be characteristic of the market as a whole.

Three different prices were given in the catalogues until 1920: wholesale, retail, and professional. After 1920, discounts offered by artists' colormen to professional artists were abolished after complaints of abuse (14).

In addition to catalogues, the archive contains a number of sample books of canvas, paper, and paints, both from Roberson and other companies, that are of great use in providing identified, untreated material for analysis. Projects have been carried out to establish the composition of the ground on the canvas samples and the pigments in the paint samples.

Price books, recipe books, and notebooks

Price books indicate both the cost to Roberson of a range of materials and the resale price. Many of the cost prices are in an alphabetical code, illustrating the importance of secrecy to the company; an alphabetical code is also used in the recipe books.

The recipe books in the archive contain a number of formulae for paints, media, and grounds, as would be expected from an artists' colorman, but also have recipes for trifle, lemon pickle, wine, boot polish, and blacking for harnesses. This illustrates the early connections between colormen, grocers, and apothecaries, professions which were separating into distinct trades in the nineteenth century (15).

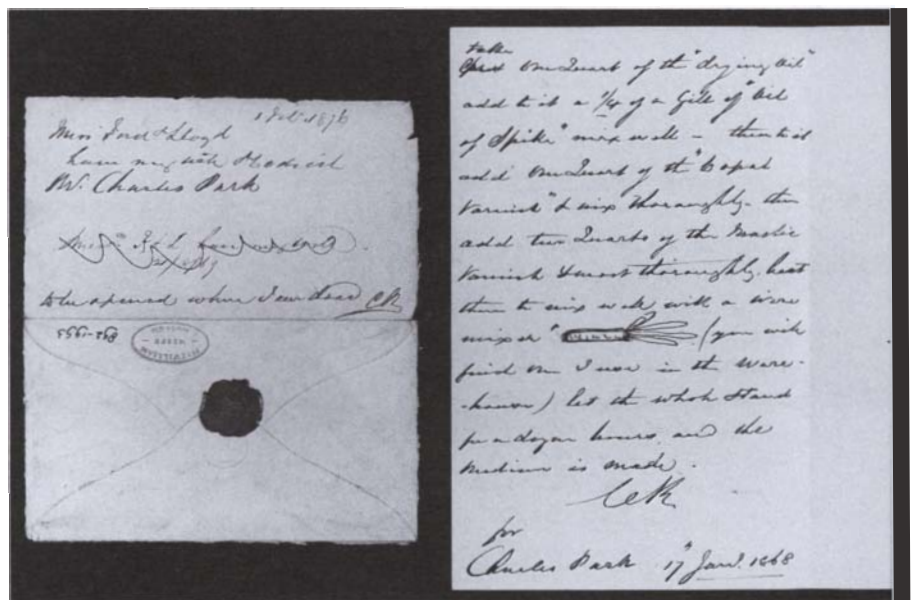


Figure 2. Charles Roberson's recipe for Roberson's Medium, originally in sealed envelope. Fitzwilliam Museum, University of Cambridge.

The books also demonstrate a degree of experimentation in the formulation of artists' colors; the composition of mixed colors in particular, such as olive green or neutral tint, was not absolutely fixed. Notes in the recipe books' margins indicate that formulae were not always successful, and in the later recipes a degree of substitution was effected (16).

The recipe books show the importance given to secret recipes and trade secrets. Many of the recipes are written in code or shorthand or have certain portions in Greek. The formula of Roberson's Medium, the company's most successful product, has been struck out in a recipe book (17). It is contained in a once-sealed envelope from Charles Roberson to his nephew Charles Park that is marked, "To be opened when I am dead," and dated 1868, ten years before Roberson's death (Fig. 2) (18). Roberson had reason for secrecy. When a Mr. Ellis advertised in the *Daily Telegraph* of 1900 that he would sell "the formula for making this famous medium for imparting permanency to oil paintings" at a price of seventy guineas, Roberson quickly threatened prosecution. Ellis's solicitors responded the next day stating that he had "no intention . . . of selling the medium as 'Roberson's Medium,'" had effected no sale of either the formula or the medium, and would discontinue the advertisement (19).

Personal accounts

The personal account books are among the most important records in the archive. They are incomplete, but provide detailed information about the materials and techniques of many of the most prominent nineteenth- and twentieth-century artists in Britain. They list in most cases what an artist bought and how much, and when he or she paid (Fig. 3). They also demonstrate the range of services Roberson would perform, such as sending workers to artists' studios to carry out a variety of tasks, transporting paintings to and from exhibitions and loaning equipment to artists. William Holman Hunt's accounts show that he frequently changed his mind as to the proportions of his paintings, and that Roberson regularly sent workers to add strips of canvas and enlarge stretchers, particularly toward the end of the artist's life.

Account holders were not only confined to artists living in Britain. Jozef Israëls in the Hague, Louis Raemaekers in Brussels, Fritz Voellmy in Basel, and the American artist Wilton Lockwood all bought from Roberson.

The accounts record extensive use of lay figures, usually rented by artists from Roberson, as their purchase price was very high (Fig. 4) There are a number

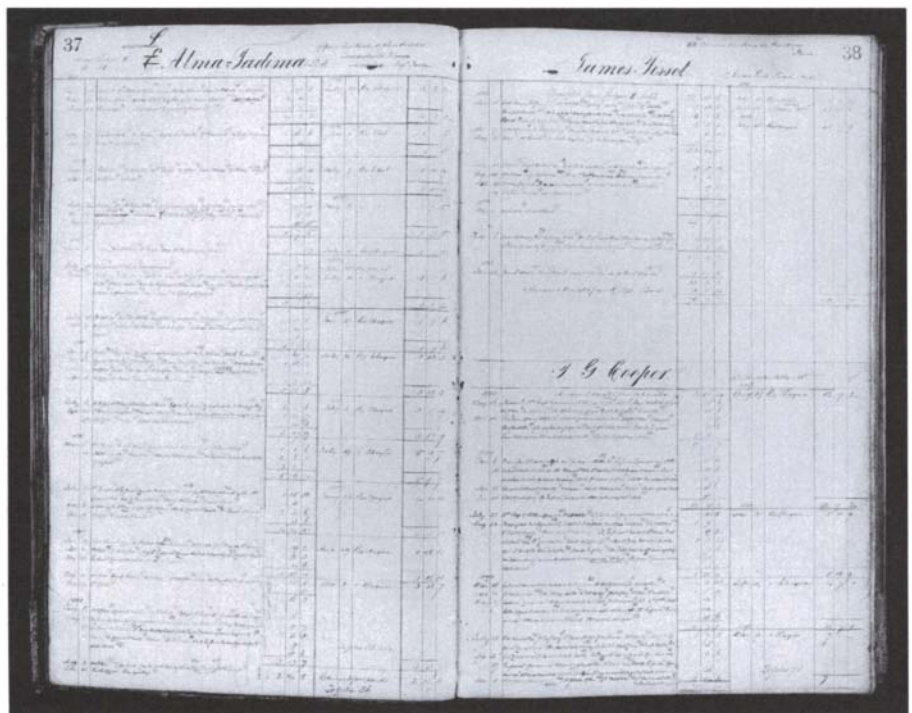


Figure 3. Personal account book, 1881–1894, MS 250-1993, 37–8. Fitzwilliam Museum, University of Cambridge.

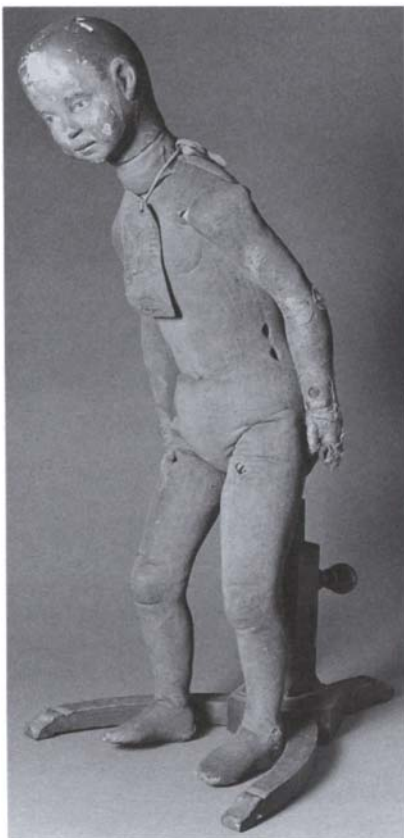


Figure 4. Lay figure: Child no. 98. Fitzwilliam Museum, University of Cambridge.

of both full- and child-size figures in the archive; their composition—stuffed knitted textile over a wooden and metal frame with papier-mâché and gesso heads—helps to explain why they were so frequently sent for repair and why Roberson entered into disputes with artists over damage sustained in use (20). Despite this, they were probably cheaper and more reliable than living models, of which Roberson kept a register to assist customers (21).

The accounts also show the range of Roberson’s customers from wealthy, well-established painters to professional graphic artists, scene painters, and others. Many amateur artists also held accounts with Roberson, including several members of royalty, both in England and abroad. Roberson appears to have been supplying the upper end of the market and although it did not hold the royal warrant for Queen Victoria, Roberson supplied the Queen with sketching materials during her reign and was granted the royal warrant to Queen Alexandra in 1912 and to King Vittorio Emanuele III of Italy in 1903. In 1949, Gerald Kelly remembered in a letter to Roberson, “When I first started painting I could not afford to deal with what I was then told was the best firm in London, but as soon as I got a little money I got my things from you, and gradually I have bought more and more . . .” (22).

Some artists had their materials specially made to their own recipes or to a formula supplied in the past which they particularly liked. Leighton asked for his paints to be made “extra stiff,” a preference alluded to in a letter from a fellow artist in 1888: “I have used your colours for several years, and I can with the greatest confidence say that they have given me every satisfaction. There is one quality which is greatly esteemed—and this Sir Frederick Leighton says is a great *desideratum*, that is *stiffness*” (23).

Roberson, however, did not always think the customers’ demands were advisable. A notebook entry dated 27 November 1882 records, “Sir F. Leighton P. R. A. in 1881, 82, had canvases prepared with different grounds made to his order & warranted *not* to stand; plaster of Paris &c. with Lac Varnish over &c. &c.” (24). In June 1888, Millais is also recorded as having “canvases prepared thickly with one coat of turpentine color to his order, also prepared his own canvases. Not warranted to stand” (25).

Bought ledgers

The bought ledgers help to complete the picture of Roberson's trading practices. They date from 1854 to 1931 and indicate the limited extent of Roberson's manufacturing activities and its widespread trade with manufacturers and wholesale suppliers, both in Britain and abroad. From this, it is possible to reconstruct the chain of supply from raw material to artist. The ledgers also show how often Roberson & Co. printed its catalogues and where the company advertised; the ledgers even give details of the fixtures and fittings of their shops and workshops.

One of the primary uses of the bought ledgers is to indicate the dating and extent of use of a variety of pigments or pigment mixtures introduced throughout the period in which Roberson traded. The popularity of a new pigment and the decline of its predecessor can be gauged from Roberson's purchases from the wholesale supplier, providing a fundamental record of the dissemination of new colors and materials.

Letters

The letters preserved in the archive are, by their nature, a disparate group of materials, but provide detailed and wide-ranging information about the company. Roberson kept much of its more interesting correspondence, particularly letters expressing approval of its products or restoration treatments. From 1919 to 1940 they also kept handwritten (and later typed) copies of their answers to correspondence. Some letters were later used in their catalogues as testimonials; for example, the letter from W. P. Frith of January 1897 referring to his painting in the Tate Gallery, London: ". . . you would like to know that it is just *fifty* years since I painted the Derby Day with your colours and medium, and that in so long a time there is no change whatsoever in the materials used" (26).

The letters also record advice both to and from artists concerning technique and the formulation and application of materials. This can often be most informative, such as Thomas Gambier Parry's letter in 1874 from Ely, where he was working on the cathedral; the letter provides both a recipe and instructions for making up the "usual common encaustic."

The letters also help to confirm information about developments within the company, such as a letter to the Factories Inspector announcing the installation of electric color grinding machinery in 1919, contradicting its catalogue note of around 1926 in which the company states that it is convinced that paints "which are ground by hand under the muller give results superior to those ground by machinery" and that the company, therefore, continued to use the former system (27). They also give some details of the conditions of the work force Roberson employed, mentioning industrial accidents and the possibility of redundancy due to ill health.

The accounts books demonstrate how long customers were prepared to delay payment of their bills and many of the letters refer to attempts to recover bad debts, using an investigation agency if necessary. This demonstrates why Roberson asked for customers to provide references from reputable London businesses before opening an account. The bad debts were not always the result of fraud. Before the establishment of the welfare state in Britain, medical treatment could be ruinously expensive; therefore illness or death often left dependents at the mercy of creditors.

Throughout the nineteenth century, artists and writers expressed unease about both the quality of artists' materials and the soundness of contemporary technique. This erupted into a public debate in 1880 when William Holman Hunt, a member of the Pre-Raphaelite Brotherhood and a long-standing customer of Roberson, gave a paper to the Royal Society of Arts that criticized the quality of artists' materials and accused the colormen of either being deceived by their suppliers or of adulterating the products themselves. Hunt's

paper resulted in a volume of correspondence and a leading article in the *Times*. The background to this can be traced in the Roberson Archive, as the anonymous colorman cited by Hunt as supplying him with adulterated paint was, in fact, Roberson.

It is significant that Hunt did not transfer his account from Roberson to another colorman and continued to buy from the company until shortly before his death. Roberson took his accusations seriously and painted out samples of pigment and made up a chart of a number of aging tests they had carried out (Plate 5). The company's concern for the quality of its pigments is evident in the twentieth century when it used a chemical laboratory to analyze samples of pigment from the wholesale suppliers. Roberson also sent materials to artists for testing; and he corresponded with both Professor Church, professor of chemistry at the Royal Academy, and Helmut Ruhemann at the National Gallery in developing and assessing materials. A project to analyze pigments in the archive for adulterants has been carried out at the Hamilton Kerr Institute with mixed results: a small number of spectacularly adulterated pigments (with much use of fillers and extenders) were found, but there was less adulteration than the literature of the time and Hunt's accusations would suggest (28).

Information from objects

The archive contains a number of objects, most of which can be identified in the company's catalogues. These objects provide a useful set of references against which to check the documentary information. For example, analysis of the pigment collection has revealed the unreliability of many of the recipe books, with adulteration and substitution being common. The objects in the collection also illustrate the development in the nineteenth century of paint containers, including both a paint bladder and the ivory pins used for piercing it, a set of brass paint syringes, the forerunner of the collapsible tube, and tubes adopted in the 1840s after they were first patented and advertised (Plate 6).

Other activities of the company

In addition to supplying artists' materials, Roberson was involved in a number of other activities that can be traced in various sources in the archive. These included restoration, dealing, and publishing. Trade directories show that it was not uncommon for colormen to be dealers and restorers in the nineteenth century, but gradually the professors came to be listed separately, although Roberson's accounts indicate that the company continued all three pursuits until its records end in the 1940s.

Historical context

Many aspects of the history of the Victorian and Edwardian period can be gleaned from the Roberson Archive. The presence of an extensive empire is felt both in terms of the materials bought from the colonies and in the products supplied, which were designed to withstand extremes of climate not experienced in Britain. Stylistic movements were also reflected in Roberson's catalogues; materials for illumination, missal painting, and heraldic hatchments became popular during the Gothic revival. Roberson also responded to the Victorian expansion in public building and the popularity of painted interior decoration by formulating a number of media and specially prepared canvases to imitate fresco. The company was involved in both supplying the materials and erecting the canvases in a number of public buildings in Britain.

Roberson also supplied materials for the great explorations of the period since, even though photography was used by this time, artists were still often sent on expeditions to record the results. A tube of yellow ochre taken on the 1912 Shackleton South Pole expedition was given to Roberson by the expedition artist George Marston on his return. When the expedition was

stranded by pack ice that crushed their ship, Marston mixed his paints with lamp wick to caulk the seams of the open boat in order to successfully fetch help. The Egyptologist Howard Carter was also a customer; he bought artists' materials, using Roberson as an agent, and sent cases of drawings of his finds to the company for distribution.

The effect of both world wars is seen, to some extent, mainly as a series of problems of supply, raw materials being difficult to obtain and materials such as paper subject to government restrictions. Some pigments were also in short supply, vermilion increasing in price by 120 percent in 1940 because of shortages of mercury, which was used for shell and mine detonators, and because difficulties with chrome colors were being anticipated as they were used for dyes for khaki and in the manufacture of poison gas (29). Roberson was fortunate in sustaining only slight damage from an incendiary bomb in 1940 and avoiding the more extensive damage experienced by other colormen.

Post-war disruption is also evident; letters from Roberson in 1919 showed the difficulties of supply and delivery facing the colormen. Canvas was in short supply, materials usually coming from Russia were unobtainable, and turpentine was scarce and expensive; even tin tubes in which to pack the colors were difficult to find (30). Similar difficulties were experienced during World War II. The world wars, the depression of the 1930s, and the rise of new reproduction methods contributed to Roberson's decline in the twentieth century.

The archive as a research resource

The Roberson Archive is chiefly relevant to the study of the materials and techniques of British artists. Its relevance outside the United Kingdom is confined to the small number of foreign artists who bought from the company and the larger number of suppliers and retailers who traded with them. These contacts include firms in all five continents, but the most numerous contacts were in France, Germany, and the United States.

The archive has been used in the last year to follow up a number of queries from both the United Kingdom and abroad. Although access will be restricted until the end of 1996 (when the cataloguing project ends), thereafter it will be available for study. A database of account holders, regarded as the most informative part of the archive, is being compiled, along with details of their purchases, and it is hoped that a checklist of account holders will be published. The database will make it possible to search for both particular artists and specific materials and, when used in conjunction with information from recipe books and catalogues, should provide a clearer picture of what paintings were made of and what artists really used in the nineteenth and early twentieth centuries.

Acknowledgments

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Notes

1. Gallagher, M. 1991. *The Roberson Archive: inventory of written and printed material*. Unpublished typescript. Cambridge: Hamilton Kerr Institute, 2. See also *Kent's Original London Directory*. 1817. Hamilton Kerr Institute (HKI) MS 785–1993, fol. 54v, 223. See also C. Roberson & Co. Ltd. 1969–1970 Catalogue, ii. Charles Roberson does not appear in trade directories at this address until Pigot's directory was published (*Pigot & Co.'s Metropolitan new alphabetical directory*. 1922–1923, 68). A letter to the National Gallery in London dated 1923 states that Charles Roberson founded the company in 1819 (HKI MS 862–1993, 293).
2. *Kent's Original London Directory*. Op. cit. (note 1).
3. HKI MS 204–1993, 638.

4. HKI MS 865–1993, 497. The move is attributed to increasing congestion caused by the growth of Covent Garden Market in a note on the firm’s history in a Roberson catalogue of 1969–1970, ii. A letter of 18 January 1940, however, states that they were not going to renew their lease on the Piccadilly branch “owing to conditions caused by the war,” HKI MS 866–1993, 47.
5. HKI MS 866–1993, 51–2.
6. The first address is 26 Rue Chaptal, the premises of E. Mary & Fils, later Geo. Mary, who gave up business in 1920. The second address is 3 Quai Voltaire, where G. Sennelier & Fils are listed between 1920 and 1935.
7. Gallagher, *op. cit.*, 3.
8. Walt, N. 1993. Personal communication. L. Cornelissen & Son, 105 Great Russell Street, London WC1B 3RY.
9. Cobbe, A. 1994. Personal communication. A full account of the arrival of the archive at the Institute is recorded in Gallagher, *op. cit.*, 3–4.
10. The archive is listed in the Cambridge Union Catalogue of Departmental and College Libraries, and was compiled by Paul Woudhuysen, Keeper of Manuscripts and Printed Books, Fitzwilliam Museum.
11. McGrath, M. 1973. *A catalogue of some eighteenth and nineteenth century patents dealing with artists’ instruments*. Unpublished typescript. London: Courtauld Institute of Art.
12. Walt, N. 1994. Personal communication.
13. Walt, N. 1993. Personal communication.
14. HKI MS 865–1993, 191.
15. This is demonstrated to even greater effect by H. Hodder, described as “Chemist & Druggist, Oil and Colorman, Tallow Chandler, Tea Dealer, and Tobacconist,” whose recipe book (1823–1858) covers food and drink, household cleaning agents, cures for both human and animal ailments, and recipes for varnishes, oils, and paints (Guildhall Library MS 16262, by permission of the Guildhall Library, Corporation of London). The preface to a 1875 Post Office Directory clarifies the separation of the trades: “Groceries in early times consisted chiefly of spices . . . but subsequently came to comprise confectionery, dyes, drugs, chemicals, whale oil, &c.; the confectioner, the druggist, and the oilman have now branched off into separate and distinct trades” (*The 1875 post office directory of the grocery and oil and color trades*. 1875, iv).
16. Townsend, J. H., L. Carlyle, S. Woodcock, and N. Khandekar. n.d. Later nineteenth century pigments: analyses of reference samples, and evidence for adulterants and substitutions. *The Conservator*. Forthcoming.
17. HKI MS 788–1993, fol. 45v.
18. HKI MS 892–1993. Charles Roberson died and was succeeded by his nephew in 1878, according to the note on the firm’s history in a 1969–1970 catalogue, ii.
19. HKI MS 891–1993.
20. HKI MS 864–1993, 142.
21. HKI MS 865–1993, 373.
22. HKI MS 527–1993.
23. HKI MS 500–1993.
24. HKI MS. 785–1993, fol. 37r.
25. *Ibid.*, fol. 41r.
26. HKI MS 597–1993.
27. HKI MS 860–1993, 30.
28. Townsend, J. H., et al., *op. cit.* See also Woodcock, S., and N. Khandekar, n.d. *The Adulteration of Twentieth Century Pigments in the Roberson Archive*. Forthcoming.
29. HKI MS 866–1993, 164, 219.
30. HKI MS 860–1993, 6, 15, 22, 83, 85.

Abstract

Two texts from Simone de Monte Dante's medieval Italian manuscript are presented here in English translation. With their many recipes, these texts shed light on the technique and materials of fifteenth-century Italian manuscript illumination and the historical development of the illuminator's craft. Studying the relationship of this manuscript to other treatises may provide a better understanding of the mechanisms involved in the adaptations and transmission of medieval art technology.



Figure 1. Rome, Biblioteca Casanatense, MS 1793, cover.

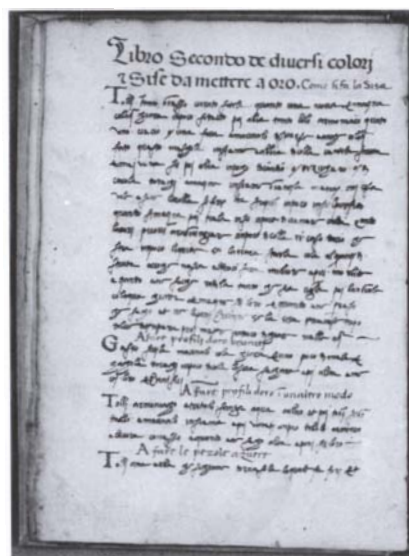


Figure 2. Rome, Biblioteca Casanatense, MS 1793, fol. 10v.

Libro Secondo de Diversi Colori e Sise da Mettere a Oro: A Fifteenth-Century Technical Treatise on Manuscript Illumination

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Introduction

The Biblioteca Casanatense in Rome holds a very interesting fifteenth-century technical art manuscript. It has the shelfmark “MS 1793” and shows on folio 2r (“r” for recto) the author’s name and the date of the manuscript: “Questo libro et ne di Simone de Monte Dante dela Zazera . . . lo chopiai el mese di novembre 1422” (Fig. 1).

The manuscript contains two closely related treatises on folios 10v–13v (“v” for verso) and 15v–20v. Written in different hands, these texts contain recipes devoted to the practice of manuscript illumination. Various aspects of the art are described, such as ink production, parchment preparation, gold leaf application, and the preparation and application of pigments and various transparent organic colorants.

The recipes in the Simone manuscript are not related to the well-known Mappae Clavicula tradition, the texts from Theophilus’ *Schedula de Diversarum artium*, the Eraclius texts, or the texts of the *Liber de Coloribus*. What makes this manuscript so important is the fact that it appears to be related to a particular group of technical art treatises comprising a number of little-known, mostly unpublished recipe texts that are specifically devoted to the miniaturist’s craft.

The relationships of parts in Simone’s treatise with those manuscripts in the Siena Biblioteca Comunale, the Modena Biblioteca Estense, the Bologna Biblioteca Universitaria, the Oxford Bodleian Library, and the Florence Biblioteca Nazionale are quite intriguing. The recipes of both treatises in Simone’s manuscript are given here in translation, with notes indicating the relationships to other recipe texts, as well as references to relevant technical literature (1).

Relationships to recipes in the well-known Bolognese manuscript are referred to according to the numbering and pagination of Merrifield’s edition (2). Relationships with two treatises in the Siena Biblioteca Comunale follow the numbering in Wallert’s edition (3). To facilitate the understanding of these relationships, Simone’s recipes—originally not numbered—are given numbers in brackets in this translation.

The Simone manuscript is clearly not written by a person with a firsthand knowledge about the products and techniques he describes. Occasionally, Simone prescribes the wrong ingredients, gives only part of a recipe, or gives some recipes in which the final outcome clearly will not be the result promised by the heading; obviously, he was not a craftsman. Sometimes his descriptions are too succinct to be fully understood by the uninitiated or modern reader. In those cases I have added to the Simone text, placing these additions in brackets to distinguish them from the original text and to make the recipes more intelligible.

With folio 10v, Simone begins a book on various colors and grounds to lay gold (Fig. 2). Following is the text of folios 10v–13v (page changes in the original will be noted here with the symbol {}):

[1] *How to make a gold ground.* Take fine, slaked gypsum, as much as the size of a nut, and grind it with a little bit of clear water. Then take Armenian bole, as much as a chickpea or a bean, and grind this separately, and also with water. Having done this, mix them together, take some dissolved glue and add it. Next have a bit of candy or sugar and some earwax and grind it gently together. The glue must be so strong that the whole matter sticks a little bit to the porphyry stone when you grind it. Then you keep it warm above some hot coals. When you work with it you can add some glue so that it will be a bit fluid. Let the dissolved glue stand a few days so that it comes from the fire with better strength. Now you can work with it. When the work is dry, scrape it until it is smooth. Then wet it with clear water and lay the gold on it. Press on it when it is dry. If the gold ground would be too weak for you, distemper it: you can put a bit of glair in the water (4).

[2] *To make lines of burnished gold.* Take slaked gypsum, grind it with glair and a bit of honey, some earwax, and a bit of glue. Let it dry [when applied], then huff on it and lay the gold. Burnish it (5).

[3] *To make lines of gold in another way.* Take [gum] ammoniac and grind it without water or anything else. Then take garlic juice and grind it with it. Next add a little bit of Armenian bole to it. Work with it. When this is done; huff on it and lay the gold on it (6).

[4] *To make the blue clothlets.* Take a plant called turnsole, of which you pick one-by-one the flowers and clustering {11r} berries. Then you put these in a mortar, according to the quantity you want to make. Crush them and press the juice out of the aforesaid berries. You put this juice in a glazed bowl and then you take pieces of cloth that are white and coarse. Then you put these into the aforementioned bowl [with the juice] and let them soak well in it. Do this three times, and every time that you take it out of the mentioned bowl, you let it dry well on a wooden bench. Before you reach this stage, make sure you find a remote quiet hole in the ground, and urinate much in it, six days before you come to make the said turnsole. Take straw and make a screen over the urine and place the cloths above the humidity of this urine. Thus it will become darker and more beautiful, and let it stand there for at least twenty days above the aforesaid urine and then the turnsole will have become beautiful.

You prepare it as follows: Take glair according to the quantity you think this turnsole needs to have to become deeply colored. When you want to work with it, take this glair in a shell or some glazed small pot and then take the turnsole and put some of it in according to the right amount and let it stand [in the glair] for an hour and then press it out with your finger and the juice that comes out of the clothlet is the turnsole. With this you can work, using a little bit at a time (7).

[5] *To make a fine ink.* If you want to make a fine ink, take one pound of galls. Break it into smaller pieces and put it in ten pounds of rainwater or water from the pot. Let it boil in a pot that has not previously been used, until the volume of this water is reduced to half. Next sieve it and throw out the substance of the galls and put the water back in after you have washed the jar. {11v} Having this done, put in five pounds of the softest white wine you can find, i.e. replacing the amount of water that has evaporated. Let it cook and when it starts to boil, put in half a pound of perfectly pulverized gum Arabic, adding this bit by bit while stirring with an iron cane until the gum is dissolved. When that is done, take the aforesaid vase from the fire and then put in half a pound of perfectly pulverized Roman vitriol. Then cover it, so that no dust can get into it and let it stand for three or four days on a quiet place, because when you leave it alone it becomes more beautiful and blacker. Then without forcing it, sieve it through a cloth into a glazed pot. And if you want this to be right, you sieve it after 15 days three times. Know that the vitriol loses its quality through smoke, that is why one does not heat it on the fire. If you cannot find white wine, you may take red wine, which

should be fresh and clear and of little color. Know that the quality of the right gum can be recognized in that it is difficult to break. The gum that comes in small grains is much better. The good quality Roman vitriol can be recognized by its blue color and [its texture], in that it is hard and grainy, like coarse salt. It is sufficiently good when the rain water or river water is soft, but better is that which comes from the fountain. Good galls are recognized by their being small and wrinkled, and hard inside (8).

[6] *To make a good yellow.* Take an egg and take out the white of it and put it in a glazed pot. Put in as much saffron as seems right to you. Take a wooden mixer and beat it so much that the egg white breaks and becomes nicely yellow. Then take a fine clothlet and sieve [the glair mixture] through it in a glazed dish and leave it {12r} in the sun to dry. Then take it out, keep it dry, and when you want to work with it, grind it with a little bit of water and a few drops of glair (9).

[7] *To make a fine lac.* Take a man's urine, as much as you need, put it in a bowl and let it stand for eight days. Then put it in a pot and let it boil so long that there is no foam anymore. Then percolate it through strong ashes, so that the liquid that comes through is like a lye. When you have sieved it; take coarse gum lac and crush it until gets the appearance of bread crumbs, put it in a new pot, and put in the said . . . (10).

[8] *To make indigo.* Take flower of woad and flour of grain. Make a dough of it with urine and with vinegar. Make a cake of it and dry it in the sun. And if it is too light, take more flower of woad and mix it again until it takes on the color you want (11).

[9] *How to make vermilion.* Take one part of mercury and one of white sulfur, as much of one as of the other. Put it in a glass bottle, thoroughly clad with clay. Put it on a moderate fire and cover the mouth of the bottle with a tile. Close it when you see yellow smoke coming out of the bottle, until you see the red and almost vermilion-colored smoke. Then take it from the fire and the vermilion will be ready (12).

[10] *To make burnished gold lines.* Take slaked gypsum, ground with glair and a bit of honey, and some earwax subtly ground together with a little bit of bone glue. Let it dry when you have applied it. Then huff on it, lay on the gold, and polish it (13).

[11] *A way to test whether the ultramarine blue is good.* Take an iron knife and hold it in the fire. Then take a little bit of the blue and put it on this knife, and if it is good {12v} it will become more beautiful and of a tender color. If it is not good, it will become black like ink (14).

[12] *To make blue.* Take a glass pot and put in it fresh sulfur and mercury, thoroughly mixed. And take two parts of sulfur to three parts of mercury. Clad the pot with white potters clay and make sure that this is thoroughly mixed with horse dung. Put this to heat well on the fire, until the smoke comes out of it. Then take it off the fire and it will be a perfect blue (15).

[13] *To make a blue water.* Take from the elder tree the berries with the kernels, at the time when they are in the stage between green and ripe. Cook them in a kettle and when they are boiled enough, take a cloth and squeeze the juice that comes out of them in a glass or glazed pot. Then temper it with urine and use it as a painter's color. When it is dry you can lightly paint with the juice of lilies with a brush on it, and it will be a blue color. Similarly, you can dye cloths with it or paper to write on with letters in gold.

[14] *How to make red lead.* Heat litharge together with rasped lead in the fire. This makes the red lead.

[15] *How to make the dark "verzino."* If you wish to make the dark verzino, take about a "quarto" of rasped brazilwood. Put it in a beaker. Take white of egg, thoroughly beaten fine with a sponge and put it for eight days in a bottle with some realgar. Mix it together after those days. Then sieve this verzino

into a glass, and put in a bit of well ground alum, of about the size of a chickpea. Then take a piece of white linen and sieve the verzino and put it {13r} in a glazed bowl and put it to dry in a place where there is no sun, until it is dry. With the verzino you can make red. When you work with it, put a little bit of it in the shell and add a little bit of clear water (16).

[16] *How to make green.* Take arzica and grind it and then you add pale azurite blue, so much that it takes the color you want. Know that the greens that are made with arzica need only a little bit of medium.

[17] *To make "purpurina."* Take similar amounts of mercury and tin and have them amalgamated together and when they thus are thoroughly combined, let it cool down and grind it together. But first take "caschina" [?], which is separately ground very well (17). Then take an oven with red hot coals and put [the ingredients] in a bottle or pot on the lit coals, and let it stand until smoke comes off, and make sure that mouth of the bottle stays open.

[18] *To take letters off from the parchment.* Take one pound of saltpeter, one pound of vitriol, and distill it. Then take a sponge, dip it into this water, rub it on the parchment and the letters will disappear (18).

[19] *To make "origno"* (19). Take lead and sulfur and nitric salt and mercury in the same quantities together and put it in a bottle of which the mouth is wide (20, 21). Put it on a moderate fire and when it starts to look glittery like gold on the mouth of the bottle, take it off the fire and it will be done (22).

[20] *To make red.* Take very well ground eggshells, treat them on the stone and put them in a new, hollow brick. And take verzino and boil it with a little bit of roche alum and pour it on the eggshells. Mix it and of this you add until it becomes as light as you wish (23). {13v}

[21] *To make the yellow "arzicha."* Take very well ground eggshells and put them in the hollow of a new brick. Take the weld herb of the textile dyers and let it boil in water with a little bit of alum. Pour it on the eggshells and thus make it as light or as dark as you wish (24).

[22] *To make green.* Take arzicha and azurite blue and mix it together and if you want to make a darker green, you must add more blue. Distemper it with gum water.

[23] *To make shades on the arzicha.* Take saffron, tempered with white of egg.

[24] *To make gold ground.* Take lead white and Armenian bole, some earwax and saffron. Temper it with white of egg a little bit of saffron and a bit of "bandoli"(?). Grind it with water.

[25] *To make letters in gold with the pen.* Take lead white, and make eight parts of it, and take an amount of honey of one of these eight parts and grind it with white of egg and a pinch of saffron.

[26] *To lay bole on gesso.* You want to mix it with glair and then grind it with clear water.

[27] *To make gold letters.* Take a bit of bole and some burned chalk, about half the amount of the bole and take three or four times as much slaked gypsum and grind it with glair.

[28] *To make lines in gold.* Take slaked gypsum, ground with glair in a bit of honey, a little bit of earwax, and a bit of glue. Let it dry. Then huff on it, lay the gold leaf on it and burnish it (25).

[29] *To make gold you can apply with the pen.* If you want to prepare gold that you can work with the pen, take beaten gold leaves—Praise God.

End. {15v}

The following text is from folios 15v–20v, one page of which is shown in Figure 3:

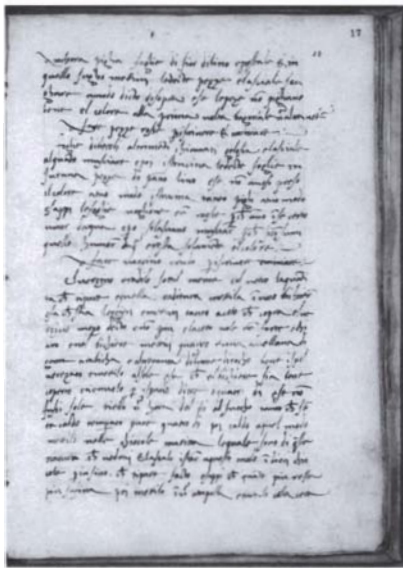


Figure 3. Rome, Biblioteca Casanatense, MS 1793, fol. 17r.

[30] *To make gum water for paints.* Take of the white gum Arabic, the quantity you need and put it in a beaker. Next take clear water and put it in this beaker, so much that it covers the gum about two fingers wide. Place it in the sun. If there is no sun, put it near the fire and let it stand there for three or four hours, until the gum dissolves. Then take it from the fire, and let it stand for two days, but {16r} make sure that you stir it every four hours. Next sieve it through a cloth and cover it until you will work with it. This is proven.

[31] *To make egg medium to temper the colors.* Take as much white of egg as you want and put it in a very clean pot. Then take four sponges bound together at the top and knead with both hands so that the white of eggs completely turns into such a froth that it will not even fall out if you turn the pot upside down. Let it stand from the morning until the evening until it settles and then put it in a bottle. And put some camphor in this bottle so that, not even after a year, will it go bad.

[32] *To make a watercolor like gold.* Take this previously described glair and put a little bit of saffron in it; and if you put in more yellow it will all be like gold.

[33] *To grind and clean vermilion for writing and miniature painting.* Take as much vermilion as you think you need, grind it very fine with water on the porphyry stone. Then let it dry on the stone. Then grind it very fine for the second time. Next put it in a glass horn and temper it with the aforesaid glair and let it stand for three or four hours until the vermilion has settled on the bottom. Then carefully decant the supernatant liquid and replace it for new glair. And keep on doing this for two or three times. Thereafter write with this on your paper. When you think it is not shiny enough, make the letters you want, large or small, let them dry and then lightly lay with the brush some of the previously described yellow on it and it will be very shiny (26).

[34] *To make green for writing and miniature painting.* Take purple lilies and pick only the petals of these. Pound them and take of the juice. You should know that this juice is of a purple color. When you add a bit of roche alum, that is, to a beaker of juice about a chestnut of well pulverized alum, it will turn blue. Then take pieces of linen cloth and put them to soak very well in this juice. Then lay it [the cloth] on the grid [to dry], and then it must be soaked another time so that it will better take on the color. And in between you let it dry on the grid.

[35] *To make blue clothlet colors.* Take certain flowers, that grow between the corn, which have five petals and have the color of a purple lily. Take the petals and rub these leaves in a piece of old linen. Let it dry and if you feel that the linen does not take enough color, repeat the treatment for a second time. You can also take the flowers that are called “fior di lebio” or “ibio,” which also grow between the corn. Pick, when you begin, the flowers that have a sky blue color and have lots of petals. Pick the petals of these flowers and squeeze them bit-by-bit with your fingers. Next press them well together, take out the juice and then soak the linen in it and let it dry on the grid. {17v} Also: take the petals of the “fior di lino” and crush them and put the pieces of linen in this juice (27). Let them dry in the same way as described before and if the pieces of linen would not take up enough color the first time, dip them in again (28).

[36] *To make red clothlets for writing and miniature painting.* Take the leaves of “bietoli,” also called “gelosia,” and let them dry a bit and then rub these leaves in a piece of linen cloth and if it does not have enough color for you, rub in more until you think it is right (29, 30). You should know that the leaves need to be dried because they have a certain humidity of water in them. Therefore, one lets them dry, which consumes this humidity, so that only the color remains.

[37] *To make crude verzino for writing and miniature painting.* Take the brazilwood and finely scrape of the quantity you think you need, with a piece of glass. Put these scrapings in a new glass. Add so much vinegar to it, that it covers the brazilwood half a finger's width, and not more. The vinegar must be strong and clear. Add to the substance in this glass the quantity of about a bean of gum Arabic and the same amount of well-pulverized roche alum. Place it in the sun and make sure that the glass is well covered. Keep it this way for three or four days. If there is no sun, then keep it for four days so close to the fire that it gets lukewarm. When it is warmed this way, put it in shells as shown here, and let it stand in these shells, until it seems done to you. Know that the longer it remains, the better it is. Next put it in a bottle. {17v} Write with this on your work. If you want to make red clothlet colors of it, dip in to soak the pieces of cloth and let them dry in the previously described way, except that in the making of the clothlets [neither] the alum nor the gum Arabic should be used.

[38] *To make a purple clothlet for writing and miniature painting.* Take the petals of the "papatello," which is a sort of wild poppy. Crush them and take out the juice. To one glass of juice it needs to have about the size of a bean of well-pulverized roche alum. Then dip in the piece of cloth, once or twice, until you think that it has taken enough of the color.

[39] *To make a beautiful blue at little cost.* Take quicklime and green and ground verdigris and sal armoniac, as much of one as of the other. Grind these all together with urine and you will see a beautiful blue. Temper it with the previously described glair, when you want to work with it (31).

[40] *To make invisible letters, which you cannot see unless near the fire.* Take sal armoniac, the amount of it is about the size of a chestnut to half a glass of water. Write with this water when it is dissolved, and if you want to read it you heat the parchment near the fire and the letters will appear as if they were written in ink.

[41] *To make black letters with every water you write.* Take galls and vitriol, as much of one as of the other. Grind it and sieve it and put it on the parchment like a varnish coating. Next write on this with any water you want and while you are writing the letters will appear black.

[42] *To erase letters from goatskin parchment without a scraping iron.* Take the juice of a lemon or of a strong orange and immerse {18r} a sponge in it. Rub with this sponge on the letters and they will be taken off as if they never had been written.

[43] *To make a ground for gold.* Take slaked gypsum, as much as you need, and Armenian bole about one third of the gypsum, and of aloe one third of the bole. Then grind everything together very fine with water on the porphyry stone. Let it dry on the porphyry stone and then grind it again very fine. Add a little bit of candy sugar and when it is ground enough, gather it in a glazed horn and temper it with equal quantities of the aforesaid glair and water of animal glue, that is hide glue. Make this gold ground so liquid that it flows from the pen and write whatever you want. And if it appears not to have enough volume, write over it a second time, like before. Scrape it carefully with a scraping iron when it is dry, so that the letter will be plane and smooth. When you want to lay the gold, huff on the letter and immediately lay the leaf of gold or silver. Press on it with the calf's tooth. Then clean it with some cotton wool so that what sticks out from the letter will be wiped off. If you want to make a head of a frame with this gold ground with the brush like described, paint it over the first application and then scrape it and lay the gold.

[44] *To make French glue for many purposes.* Take animal glue, i.e. bone glue, and put it to soak in so much water that it covers the glue. Put it to soak in the evening and put it on the fire in the morning. When you soak it, it does not matter {18v} if there is not enough water to cover it completely, because

when the lather covers it about the width of a finger it is good enough. When you have had it cooking for a while, take it from the fire and immediately add four or five hard and fresh pieces of chicken dung. Then you sieve it through a straining cloth, without wringing it. Then put as much as you need of it back in the water and use it as it pleases you.

[45] *To color and lay gold on oranges and other fruits.* Take previously described glue and douse your hands in it. Rub with these washed hands the orange or any another apple very well. Let it dry. Then wet your hands again and rub this fruit again until it has taken on the glue well. Then give it the color you want it to take. But if you wish to be it in gold, be it as letters or in gold leaves, do as follows: Take armoniac, very well ground with urine on the porphyry stone. Distemper it with urine, but not so much that it flows from the pen, because the letters or the leaves want to be done with the brush over the colors with this armoniac. Let it dry. Next take the gold leaf and put it on the letters. But you should know that the letters first need to be warmed up with the knife. Then, when the gold is laid, immediately press lightly on it with cottonwool. Then rub with the cottonwool over the letters so that the gold that does not adhere to the letters is taken off. You can also give it beautiful, nice colors.

[46] *To make a tragacanth gum paste of any color you want, to make reliefs.* Take as much tragacanth gum as you want and put it in a glass or a dish, and add so much vinegar that it covers the tragacanth. But the vinegar you put in should be strong. Let it stand to soak for two days and two nights. Then take slaked gypsum which is dry. Next take lead white and triturate it very well with the tragacanth in a mortar. But put on the bottom of the mortar {19r} a bit of the gypsum so that the lead white and the tragacanth will not stick to the mortar. To prevent it from sticking to the pestle, put also some gypsum on that. Pound it well and it will become a paste as white as cottonwool. If you want the paste to become black, do as follows: Take a lit candle and over the flame you hold a piece of tinned iron so close that it touches the flame, whose smoke will deposit in a black spot. Take this deposit and rub it together with the paste. And the more you put into it the better it will be. Grind it with indigo if you want it to be blue, and if you put in little, it will be light blue, and it will be dark blue if you put much more indigo in it. If you want it to be red, put in vermilion which has been finely ground on the porphyry stone. The more you put in, the redder it will be. If you add little of it, it will be of a flesh tone. Put in a bit of well pulverized verdigris if you want it to be green. If you want it to be yellow, put in some well ground orpiment. If you want it to be a purple color, put in a bit of lac. Know that the more of these colors you put in, the stronger colored it will be. The paste you thus make should be a little bit harder and you make it in such a way that you grind it again many times with the previously mentioned things. To make a good paste and to prevent it from sticking, either to the mortar, or to the pestle, knead a piece of it in your hand. When you want make it in a mold, take some of the soft paste that fits on the blade of a knife, or even less. But if you want to let it harden in a lead or clay mold, clad the form with some cotton so that the paste will not get stuck to the mold. Apply some warm bone glue in the areas where you want to do some modeling or make foliage. That will do it.

[47] *Papier mâché to make reliefs.* Take scraps of the paper cuttings from books and put them to boil in a kettle. When it has boiled, take the scraps out and pound them fine in a bronze {19v} mortar. Then let it boil a second time. Take the kettle from the fire once it has boiled and let it cool down. When it is cold enough to have your hands in it, take this paper pulp out. Squeeze the water out, make balls of it and let them dry. When you want to make reliefs with it, put these balls to soak in hot water during one or two days. When the water is cooled down enough to have your hands in it, break the balls and stir. It will become like a dough. This paste spreads smoothly. Apply

it on what you are working, with a scuffle, so that it spreads. Press everywhere on it with a sponge, as you work with the paper pulp without glue.

[48] *To make cork board for making relief.* Take good writing paper, which is smooth and with a little glue. Place them between washcloths. Always fold the cloths in four quarters, placing the paper in between. Put it in boiling water, making sure that it does not become brownish or stained by lye. Then take it out and let it dry on the grid. When it is a bit dry, you can work with it. It is best to work with water, so warm that you can just stand to have your hand in it.

[49] *To make letters, big or small, in gold.* Take the milky juice of a fig tree and put as much as you think you need in a dish. Next take good black ink, which is rich in gum, and put so much of it in that the juice looks black. Write with it. When the letters are written, you huff on it and immediately lay the gold on it. Burnish with the tooth, and then rub the letters with cottonwool and where you have huffed on the ground, the gold will stick and the rest will be taken off (32).

[50] *Another way.* Take Armenian bole and grind it with clear water very fine on the porphyry stone. Let it dry on the stone. Then grind it again with water and let it again dry on the stone. Then grind it again with the aforesaid milky juice. When ground, {20r} gather what you have in a horn of glass, or of glazed earthenware. Temper this so much that it flows from the pen.

[51] *To make secret writings.* Take well pounded and sieved galls and put it to soak in water. Let it stand in the water until it settles to the bottom. Four glasses of this powder go to one glass of water. Write with this water whatever you want. Take, when you want to read it, vitriol and put it in water, with which you wet these letters. The letters, which you will be able to read, will now appear.

[52] *To make the blue clothlet.* Take a plant which is called turnsole whose flowers and clustering berries you pick one-by-one. Then you put these in a mortar, according to the quantity you want to make of it. Crush them and take the juice out. Put this juice in a glazed bowl and then you take pieces of cloth that are white and coarse. Then you immerse them in the bowl [with the juice] and let them soak well in it.

Do this three times, and every time that you that you take it out of this bowl, you let it dry well on a wooden bench. Before you reach this stage, you have to find a remote quiet place in the ground, and urinate much in it, six days before you come to make the said turnsole. Then, to place it above the humidity of this urine, take straw and make a fabric over the urine, and place the cloths on it. Let it stand for at least twenty days above the aforesaid urine to make it darker and more beautiful.

The best turnsole is made in this way: First, take glair according to the quantity you want to make. You may wish to use amounts small enough that the said turnsole will be {20v} strongly colored. When you want to work with it, take the glair and put it in a shell or in a small glazed jar. Then take the turnsole and put some of it in, according to the right proportion and let it stand [in the glair] for an hour. Then press it out with your finger and the juice that comes out of the clothlet is the turnsole. Always prepare a little bit at a time because that is better.

Notes

1. Constraints of space in the present volume made it impossible to publish a true bilingual text edition (with a transcript of the original printed next to the translation). A copy of my transcript, however, is available upon request.
2. Merrifield, M. P. 1849. *Original Treatises, Dating from the XIIth to the XVIIth Centuries on the Arts of Painting in Oil, Miniature, Mosaic, and on Glass; of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems*, Vol. II. London: John Murray, 325–547. References to the so-called Bolognese manuscript (Segreti per

- Colori, Biblioteca Universitaria MS 1536) are given as Bol. MS, followed by recipe number and page number in Merrifield's publication.
3. Wallert, A. 1991. *Kookboeken en Koorboeken, Techniek en productie van boekverluchting in koorboeken van het klooster Monte Oliveto Maggiore*. Groningen: Groningse Universiteits Drukkerij. References to Ambruogio da Sienas Rícepte daffare piú colori, Siena Biblioteca Comunale MS I.II.19, fols. 99r–106r, are given as Siena MS I, followed by recipe number and page number in Wallert's edition. The indication Siena MS II with recipe and page number refers to the edition in the same publication of Bartolomeo da Sienas *Experientie*, Siena Biblioteca Comunale, MS L.XI.41, fols. 34v–39v.
 4. This recipe is an abbreviated version of Siena MS II, XVIII, p. 45. A version in Latin of the same recipe is in Bol. MS, 160, p. 467.
 5. Alexander, S. M. 1965. Medieval recipes describing the use of metals in manuscripts. *Marsyas* (XII):34–51.
 6. An identical recipe is in Siena MS I, recipe XXIV, p. 35. An abbreviated version of this recipe is in Oxford (Bodleian Library, MS Conon. Misc. 128, fol. 2v): "A mettere oro in carta."
 7. Wallert, A. 1990. *Chrozophora tinctoria* Juss.: Problems in identifying an illumination colorant. *Restaurator* (11):141–55.
 8. Identical recipe in Siena MS I, XVIII, p. 31. Similar descriptions of ingredients are given in Siena MS II, III, p. 37; Bol. MS 389; and Bol. MS 390, p. 597. Also see Zerdoun Bat-Jehouda, M. 1980. *La fabrication des encres noires d'après les textes*, *Codicologica* 5; *Les matériaux du livre manuscrit*, *Litterae textuales* Leiden.
 9. Kühn, H., 1961, Safran und dessen Nachweis durch Infrarotspektrographie in *Malerei und Kunsthandwerk*, *Leitz-Mitteilungen für Wissenschaft und Technik*, Bd 11, (1):24–28. See also Straub, R. E. 1965. Der Traktat "De Clarea" in der Bürgerbibliothek Bern, *Schweizerisches Institut für Kunstwissenschaft, Jahresbericht* (12):89–114.
 10. The same but more complete recipe can be found in Bol. MS 129, p. 447.
 11. Identical recipe Siena MS I, XXIII, p. 35. This recipe recurs in a slightly more elaborate form in Oxford, Bodleian Library, MS Conon. Misc. 128, fol. 21r and also in Bol. MS, 77, p. 415, and Bol. MS, 80, p. 417.
 12. Brachert, F. and T. 1980. Zinnober. *Maltechnik / Restauro* (86):145–59.
 13. Siena MS II, XIV, p. 49.; Siena MS I, XV, p. 29.
 14. Siena MS II, XII, p. 41. Also see Kurella, A., and I. Strauss. 1983. Lapis lazuli und natürliches Ultramarin. *Maltechnik / Restauro* (89):34–55.
 15. This recipe will not result in the promised blue pigment, but rather in the formation of the red mercuric sulphide. On the "azure-vermilion tangle," see Thompson, D. V. 1956. *The Materials and Techniques of Medieval Painting*. New York: Dover Reprints, 155.
 16. An identical recipe can be found in Siena MS I, XII, p. 29. Also similarities with Modena, Biblioteca Estense, MS α .T.7.3., fol. 10v. Also see Wallert, A. 1986. Verzino and Roseta Colours in 15th Century Italian Manuscripts. *Maltechnik / Restauro* (92):52–70.
 17. The recipe requires at this point the use of sulphur to be practically applicable. It is not clear what is meant by "cashina."
 18. Similar in Siena MS I, XXI, p. 32, and Siena MS II, XXI, p. 46.
 19. Probably a corruption of "porporino," a golden glistening tin (II) sulphide.
 20. The recipe calls for lead. Any useful pigment, however, can only be obtained if this lead were replaced with tin.
 21. The nitric salt, "sal nitro," should have been "sal armonico," i.e., ammonium chloride.
 22. This recipe is slightly more intelligible than Simone's recipe 17. See Schiessl, U. 1981. Musivgold, eine pigmentgeschichtliche Skizze. *Maltechnik / Restauro* (87): 219–30.
 23. Florence, Biblioteca Nazionale, MS Magliabecchiana CL XV 8bis, fol. 14v. More elaborate variations are in Siena MS I, III, p. 23, and in Florence, Biblioteca Laurenziana, MS Ashburnhamia 349, fols. 80v–81r.
 24. The weld herb of the dyers is *Reseda luteola* L. See Stoll, A. M. 1981. Gelbe Pflanzenlacke, Schüttgelb und Safran. *Maltechnik / Restauro* (87):73–111.
 25. An identical recipe can be found in Florence, Biblioteca Nazionale, MS Palatina 916, fol. 110r, "Affare profili d'oro brunito." A related recipe occurs in Bol. MS, 162, p. 469.
 26. This recipe occurs in a slightly more elaborate version in Siena MS II, VI, p. 39.
 27. *Fior di lino* is the cornflower, *Centaurea cyanus* L.

28. On these “clothlet colors,” see Wallert, A. 1993. Natural organic colorants on medieval parchment: anthocyanins. *ICOM Committee for Conservation Preprints*, 516–23; and Willhauk, N. 1981. Farbprobleme spätmittelalterlicher Buchmalerei. *Restaurator* (1–2):103–34.
29. *Bietola* is a beet or garden beet; *bietolina* = weld (*Reseda luteola*) (?).
30. A plant with the same name, *gilosia* (*Amaranthus tricolor?*), is mentioned in Bol. MS, 117, p. 439, for making a purple clothlet color.
31. Gettens R. J., and E. West Fitzhugh. 1966. Azurite and blue verditer. *Studies in Conservation* (2):54–61.
32. Quite similar is Siena MS I, IV, p. 22. In Simone’s manuscript, however, the vermilion prescribed by Ambruogio is replaced for a black ink. The recipe recurs in a rather abbreviated version in Florence, Biblioteca Laurenziana, MS Ashburnhamia 349, fol. 84v.

Abstract

Primary sources can be extremely valuable for the study of historical painting techniques, materials, and studio practice. Most authors of these treatises and manuals are either anonymous or little known. Quite often, therefore, no context for these books can be traced. In some cases, however, research on the author(s), if known, can reveal information that helps to interpret these sources, shedding light on the contents and their function in studio practice. An example can be found in a seventeenth-century Italian treatise on miniature painting which, according to its title, was written by the miniaturist Valerio Mariani da Pesaro in 1620. Research on this treatise has revealed some unexpected aspects of its authorship.

A Seventeenth-Century Italian Treatise on Miniature Painting and Its Author(s)

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The manuscripts

The Leiden University Library owns a seventeenth-century Italian manuscript titled *Della Miniatura, del Signor Valerio Mariani da Pesaro, Miniatore del serenissimo Signor Duca d'Urbino, del Signore Capitano Giorgio Maynwaringe, inglese, l'anno del Signore 1620, in Padova* (sign. Voss. Ger. Gall. 5q). The manuscript, consisting of three sections, contains a treatise on miniature painting technique. The first section covers technical recipes for the preparation of pigments, dyestuffs and inks, binding media, and utensils such as pencils and brushes. The second section gives instructions on how to paint landscapes, and describes the mixtures of colors to use and the build-up in layers for the execution of different types of trees, weather conditions, water, sea, rocks, plants, mountains, villages, close-up and distant views, and so forth. The third and smallest section describes the mixtures of colors and the layering of colors used to depict skin and cloth in portrait painting.

The recipes in the first section seem to be quite accurate, a result in part of the continuation of traditional methods, and in part of personal experiments by the writer. In general, one can say that the technique described is a watercolor technique for paper and parchment, in which the final effect is reached by using a mixture of pigments and dyestuffs or, as is more often and more typical for this treatise, by several layers of washes of colors.

During the research on the treatise, two more manuscripts were found to be connected with the Leiden manuscript. One manuscript, owned by the Beinecke Library, Yale University (sign. MS 372), is entitled *Della miniatura del Signore Valerio Mariani da Pesaro, miniatore del Duca d'Urbino con aggiunte d'altre cose per l'istessa professione dal Signor D. Antonello Bertozzi scrittore e miniatore in Padova, per me Francesco Manlio Romano, l'anno MDCXX*. The second manuscript, entitled *Ricordi di belli colori*, is part of the Urbinati Latini collection in the Biblioteca Apostolica Vaticana, Città del Vaticano, Italy (sign. Urb. Lat. 1280). The three manuscripts will be referred to here as the Leiden, Yale, and Rome manuscripts.

The Yale manuscript, despite the differences in its title, is very similar to the Leiden manuscript, with only some minor variations in language. It contains, however, some extra pages at the end with additional recipes for pigments, paper dyeing, etching materials, as well as recipes for gunpowder, payments for books, a list of the quarters of Venice and other notes, some of them dated between 1614 and 1628. The extra recipes could be the “aggiunte d'altre cose per l'istessa professione dal Signor D. Antonello Bertozzi scrittore e miniatore in Padova.”

The Leiden manuscript contains a price list of pigments and dyestuffs and also a list of all materials needed by the *miniature*. Both are lacking in the Yale manuscript (see Appendix doc. 1).

The Rome manuscript covers only the second part of the Leiden and Yale manuscripts, that is, the part on landscape painting. We find here many differences in language and also in the sequence and length of the chapters. The Landscape section in the Leiden and Yale manuscripts is more extensive, as

it also includes instructions for composition, the build-up of a miniature from a pencil drawing up to the final execution in paint, and so on. Some chapters are a combination of two or three short chapters from the Rome manuscript, covering more or less the same subjects. It seems that the writer of the treatise rearranged and expanded the text from the Rome manuscript to improve the contents (1).

Valerio Mariani da Pesaro

The miniaturist Valerio Mariani da Pesaro—the writer of the treatise, according to its title—is mentioned by Thieme-Becker as being active from 1560 to 1600, and by Zani as living from 1565 to 1611, but further information on the treatise and its author seemed difficult to find (2). Archival research in Italy however proved otherwise, and the treatise can now be provided with an ample context.

Mariani is described in Lancellotti's *L'Hoggi di* (1636) as a pupil of Giovanni Maria Boduino, a miniaturist who worked in Friuli (3). In a document from 1582, Mariani is mentioned as the twelve-year-old pupil of Boduino, establishing Mariani's date of birth as 1570 (4). About Mariani's working environment after his training in Friuli, little information has been found so far. He worked, as he mentions in the treatise (Chapter XVI: *Giallo Santo*), for the Duke of Savoy: "*Giallo santo* is a colour which is extracted from the flower of the broom, as a painter in Borgo in Brescia taught me, while I stayed in that place in the service of the honourable memory of Duke Emanuele Filiberto, Duke of Savoy . . ." (5). And, as can be read in the title of the treatise, he was also employed by the Duke of Urbino. According to the date of the treatise, this must have been Francesco Maria II della Rovere. The last known dates in Mariani's chronology are 1618, when he is mentioned as heir in his brother's will, and 1625, when he is mentioned as a *debitore* in the duke's bookkeeping (6).

So far no documents on his work for the Savoy court or other employers have been found; therefore, we concentrate on Mariani's activities for the Urbino court, which provides us, as will become clear, with the context in which the treatise was written.

Francesco Maria II della Rovere began his reign in 1574, after his father Guidobaldo II della Rovere died, leaving him with a bankrupt state. The young duke, who had a strict and sober upbringing at the court of Philip II, started a period of severe economizing, including trimming the court's cultural expenses. It was 1580 before the duke regained interest and renewed his financial backing for cultural and artistic activities. Many documents, as well as artworks he commissioned, survive the period of his reign, creating a clear image of the cultural policy and interests of the duke (7).

As a contemporary chronicle states, "When Francesco Maria, the last Duke, had paid the large debts of his father Guidobaldo by stopping the many arts and famous crafts that were executed here, he changed his mind after seeing the severe consequences and ordered the foundation of several workshops at his court where very excellent masters in every art and profession were put to work" (8). One such master was the miniaturist Valerio Mariani da Pesaro. These workshops formed a well-organized business, providing artworks "to order" for the duke. As not only masters but apprentices were present, the workshops seem to provide the appropriate milieu for writing a technical manual. A sketch of the workshops will, therefore, be given.

The workshops

The duke made personal notes during the years 1580–1620 of all his "artistic expenses," including monthly payments to the *botteghini* (workshops) (9). He employed painters, sculptors, watchmakers, ebony workers, bookbinders, goldsmiths, and miniaturists in a lively and businesslike organization (10).

The actual working areas of the botteghini were situated on the ground floor in the left wing of the ducal palace in Pesaro. There seems to have been an internal entrance from the palace (11). The botteghini also opened onto the street like small shops; indeed, the artists were permitted by the duke to accept orders from other clients. Some artists had their living quarters above the workshops; others who had families received money to rent housing elsewhere in Pesaro. They also received provisions, candles, and firewood, as can be read in a ledger (12).

A supervisor was appointed with responsibility for the daily organization, provisions, and the supply of materials. Bills with lists of ordered materials, including pigments and brushes, are among the many surviving documents concerning the workshops (see Appendix doc. 2). The duke's commissions were not given by the duke personally but passed on by intermediaries, mostly noblemen employed as his secretaries or persons suitable because of their profession. These intermediaries also acted as the duke's representatives in the search for artists and artisans for the workshops. For example, the duke's ambassadors were ordered to search in Rome, Venice, and Florence for artists of the highest quality. The proposed artists had to send proof of their capacities which, according to the documents, was quite often rejected by the duke.

In 1581 the duke asked his ambassador in Rome, Baldo Falcucci, to find him a miniaturist. From 1582 on, a "miniature" is mentioned in the lists of workshop employees (13). In many instances, the name of the artist is not given but a "maestro Valerio miniatore" appears from 1603 to 1605. Although employee lists from 1605 on are missing, Mariani's activities at the court of Urbino most likely continued.



Figure 1. Detail from the Battle of San Fabiano, illustrated in Plate 7a, showing the center scene where the sketchy underdrawing is clearly visible. Photograph by E. Buzzegoli, Laboratorio di Restauro. Courtesy of the Uffizi Gallery, Florence.

Mariani's activities can be traced not only in documents but also in many miniatures. The Biblioteca Apostolica Vaticana has three illustrated manuscripts attributed to Mariani, in addition to a part of the *Purgatorio* and all the miniatures of the famous Dante Urbinato's *Paradiso* (14). The Galleria Palatina in Florence owns two series of miniatures, framed in black ebony frames, with scenes from the lives of Christ and Mary, miracles, and martyred saints. The Uffizi owns the only miniature with Mariani's signature, a battle scene from the life of Federico da Montefeltro (15) (Plate 7a). This miniature is of great interest as we can compare the techniques used with those as described in the treatise, thus comparing practice with theory. The miniature is kept in a dark cabinet; the colors are, therefore, in extremely good condition. A study of the miniature using microscopy made clear that the standard technique of washes was used. Specific comparisons (i.e., the build-up of the trees, background with the village, bluish mountains and sky, etc.) with chapters in the landscape section of the treatise, show that Mariani is following the instructions given there. The miniature has a very sketchy underdrawing—which can be seen with the naked eye but is even more clearly apparent with an infrared camera—that has been traced in some places with a brownish ink (Fig. 1) (16). A blue-black ink is also used to emphasize contours and shadows. On the underdrawing, the paint is most often added in transparent layers using the techniques described in the treatise.

Mariani was known for his technical abilities; Lancellotti described him as a pupil of Boduino who "surpassed his master in patience, and his miniatures were owned by the most important princes in the world." They both "kept a secret of how to grind gold in the Persian way for miniature painting and writing, that stayed stable as the antique [gold]" (17).

Although the preceding paragraphs comprise a short résumé of the research results so far, it is clear that we are considering a treatise that can be placed in an interesting context, offering a unique possibility of comparing the theory of the treatise with the practice as laid down in Mariani's work. The context of the workshops, and Mariani's obvious technical skills, make it plausible that the treatise was written as a manual to be used in the workshop.

Ricordi di belli colori

Initially it seemed reasonable to assume that the Rome manuscript was written by Mariani as a draft version of the landscape section. The manuscript was then reworked and expanded for the larger treatise of which, presumably, both the Leiden and Yale manuscripts are copies. However, there are some remarkable features that made us continue the search for the origin of the Rome manuscript, leading to interesting results.

The manuscript's text covers most of the chapters on specific landscape elements that are present in the Leiden and Yale manuscripts, but lacks the chapters on composition and underdrawing. There are also considerable differences in the order and composition of the chapters and in the language, as well as some repetitions and crossing out of text. First, a comparison with other Italian treatises on painting technique from the sixteenth and early seventeenth century shows that no specific attention is given to landscape painting, especially not in such great detail as we see in the Rome manuscript. Landscape painting of that period was simply a Flemish specialty. It reached its peak after Pieter Breughel the Elder introduced the new spatial concept of several planes leading to a distant vista in which the religious theme became a detail instead of the main, foreground scene. The landscapes produced by the many Flemish artists working in Italy were enormously popular, and landscape print series circulated widely (18). The Rome treatise seems to reflect a Flemish sense of detail concerning landscape elements, an idea supported by the presence of Flemish painter Michiel Gast's name in a chapter on how to paint villages in the background. Gast's methods are found to be exemplary. We know little about Michiel Gast today except that he came to Rome as a pupil of Lorenzo of Rotterdam and was known for his paintings of ruins (19). The citation of Gast's methods and the detailed attention to landscape elements suggests a strong Flemish influence on the author of *Ricordi di belli colori*.

Another remarkable feature of the Rome manuscript are the chapters on flowers and plants. Although the plants described are quite common in Italy, the names used are often botanical ones, probably most familiar to a person with a special botanical interest. In these chapters some personal remarks are present. For example, the writer says, "I have made a yellow flower in my book with herbs, the biggest one without landscapes" and "to represent well the fruit of the *fusaina* or otherwise *nocella* as that is how it is called in the village of Rocca Contrada." It is striking that all such personal remarks made by the author are omitted in the landscape section in the Leiden and Yale manuscripts, while personal remarks are retained in the sections of those manuscripts containing recipes for pigments and dyestuffs.

A reading of the manuscript suggests that the writer lived in Rocca Contrada, painted landscapes, came from a Flemish background (or was strongly influenced by Flemish landscape painting), had botanical interests, and probably illustrated a herbarium. Knowing this, should we still consider Valerio Mariani da Pesaro as the writer of the Rome manuscript or should we look elsewhere? It was in fact the citation of Michiel Gast's name which helped us to answer this question.

Gherardo Cibo

One of the very few known works by Gast can be found in the collection of Gherardo Cibo, an Italian nobleman-artist-botanist (1512–1600). Cibo lived for most of his life in the small village of Rocca Contrada, now called Arcevio, in the Marche, the region of the Duchy of Urbino. Cibo started an ecclesiastic career in Rome but he did not pursue it, settling in 1539 in Rocca Contrada where he occupied himself with artistic and botanical activities. Although in obscurity until the 1980s, research has revealed that Cibo was responsible for many landscape drawings in major collections that had been anonymous or wrongly attributed, often to Flemish artists (Fig. 2). A 1989



Figure 2. Gherardo Cibo, Landscape. Courtesy of the Printroom of the University of Leiden, the Netherlands (inv. nr. AW 441).



Figure 3. Gherardo Cibo, “Hemionite,” from Herbarium (MS ADD 22332), fol. 143r, ca. 1570. Courtesy of the British Library.

exhibition and catalogue dedicated to Gherardo Cibo shed much light on the artist’s career and personality (20). A large group of landscape drawings, several herbaria, and illustrated editions of Mattioli’s translated version of Dioscorides can now be attributed to Cibo (Plate 7b, Fig. 3). According to contemporary testimonies, Cibo must have been an interesting personality who came from a wealthy family. Praised by the local population for his virtues and charity work, Cibo occupied himself with botanical expeditions and painting. A local seventeenth-century historian alludes to Cibo’s high artistic qualities and his method of preparing colors by extracting the dyestuffs from herbs, fruits, and seeds (21).

Could Gherardo Cibo be the writer of *Ricordi di belli colori*? Proof was to be found by comparing Cibo’s works with the Rome manuscript. In the manuscript we not only find instructions on the mixtures of colors and the build-up of transparent washes of paint to achieve certain effects but also instructions specifically directed toward working on pen drawings or prints (i.e., Chapter XXIX: “Beautiful green to use on prints and on plants drawn with pen”; Chapter XXXVI: “To colour herbs, printed or drawn with pen”). Cibo’s works show that he did both. Many of his landscape drawings were executed in pen and ink and then colored with transparently applied colors. He also colored prints in several editions of Mattioli’s translation of Dioscorides and added landscape backgrounds as a personal touch.

Additional proof can be found in the text. The personal remarks cited above concerning the chapters on plants point to the herbaria illustrated by Cibo. Two of these drawings are kept in the British Library (22). The largest herbarium illustrated contains only plants, drawn in ink and colored with watercolor, without landscapes in the background: “. . . my largest book on herbs without landscapes.” The other smaller herbarium does have landscapes; on folio 183v, one reads, “Fusaina salva[ti]ca, nocella qui chiamata a Roccha C[ontrada],” which corresponds fully with the first lines of Chapter XLV of the manuscript, in which the instructions on how to paint this flower are given. The author describes several color mixtures for the *fusaina* or *nocella* flowers and folio 184v in the herbarium can be found many color samples and some *fusaina* flowers where these mixtures are apparently tested (Figs. 4, 5).

Finally, examination reveals that the Rome manuscript is written in two hands. One author wrote only two pages; the script on these pages can be



Figure 4. Gherardo Cibo, “Fusaina [. . .] nocella qui chiamata a Roccha C[ontrada],” Herbarium, (MS ADD 22332), fol. 183v. Courtesy of the British Library.

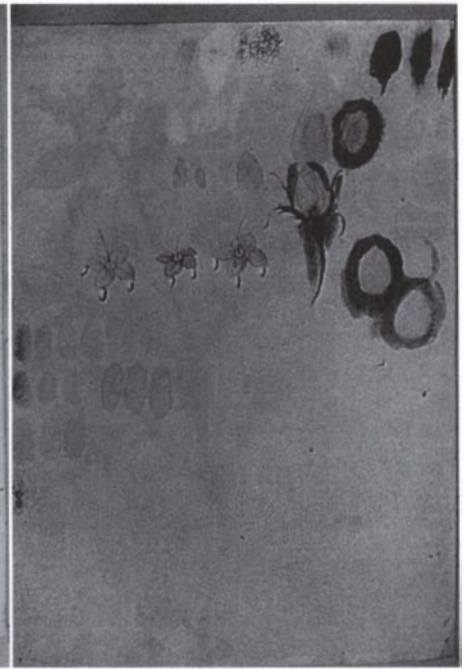


Figure 5. Gherardo Cibo, several proofs of colors and “Fusaina” flowers, from Herbarium (MS ADD 22332), fol. 184v. Courtesy of the British Library.

identified as Cibo’s handwriting. The conclusion must be that Cibo—not Mariani—was the author of the Rome manuscript.

Gherardo Cibo and Valerio Mariani da Pesaro

Although Gherardo Cibo’s part in the origin of the treatise is established, we may still assume that Valerio Mariani composed the treatise, using Cibo’s specific knowledge and thus incorporating the section on landscape painting. There is no reason, thus far, not to assume that Mariani wrote the first section with technical recipes, especially as some personal notes present cannot be attributed to Cibo, pointing to a professional miniaturist who was working on a commission basis.

Did Cibo and Mariani meet? Cibo died in 1600 when Mariani was thirty years old. His name appears in the employee lists for the first time in 1603, which does not indicate he was not working in Pesaro before that date, as most of the time the workshop employees are only indicated by their function (i.e., *miniature*) and the duke had started his search for capable miniaturists in 1581. If they did meet, Cibo must have been in his late seventies or early eighties but still active, as a letter he wrote to the Duke Francesco Maria II della Rovere indicates. In the letter, dated 1580, Cibo tells the duke he is very honored by his request to illustrate an edition of Mattioli’s Dioscorides; Cibo finished the work at nearly seventy years of age (23). This letter, however, also indicates a clear contact between Cibo and the duke, but there were apparently more contacts with the Urbino court.

In the Biblioteca Comunale in Jesi (Marche, Italy), an album is kept with landscape drawings, mainly by Cibo. The text on the cover of the album is in Cibo’s handwriting and says that the album contains “a little landscape on paper from the hand of the Flemish painter who serves our illustrious Duke of Urbino, which Sir Cavaliere Ardoino sent me, in April I think. 1591. And he names himself M[aestro] Giovanne. There are here two drawings of M[aestro] giovanne fiamen[ese] from landscapes on coloured paper. . . .” It also mentions drawings of “the Painter from Forlì” (24).

Cavaliere (knight) Ardoino can be identified as Girolamo Ardoينو (also Ardoينو or Arduini), the duke’s architect (25). In many documents, he figures

as an intermediary between the duke and the workshops. Maestro Giovanne Fiamengo and the Pittore da Forlì both appear in the many documents concerning the workshops as being employed by the duke. Cibo was obviously acquainted with Ardovino and, therefore, must have been familiar with the workshops and the artists working there. He might have known the young Mariani if the latter did arrive in Pesaro before 1600. In any case, he probably knew the miniaturists' workshop.

The connection

As mentioned earlier, the Rome manuscript is written in two hands. The two pages in Cibo's handwriting comprise two chapters, one chapter on the mixture for meadows and fields (with two color samples in the margin), and one chapter with more general instructions on mixtures of colors (see Appendix doc. 3). At the end of the latter chapter, the following is written: ". . . such that if you Sir, will try to be a little less lazy and exercise more often, the exercises will work out very well." This last sentence makes clear that the manuscript was intended as a manual for someone who wanted to learn, or was ordered to learn, to paint and draw landscapes like Cibo did, that is, in the Flemish way. Although the manuscript is part of the Urbinati Latini collection of the Vatican Library, it seems unlikely that it was written for the duke himself, as the final remark is not very suitable for addressing a duke. It is reasonable to assume, however, that the duke, obviously impressed by Cibo's artistic capabilities, asked him to write down his techniques for the execution of landscapes in the Flemish manner in a manual that could be used by the duke's miniaturists' workshop. The different handwriting, corrections, and repetitions may indicate that Cibo dictated the text to someone, except for the chapter in which he addresses the person for whom the manuscript was meant. This person might have been the young Mariani. If not, then Mariani found the little book on landscape painting, reworked it, and included it in his treatise. The pigments and dyestuffs that appear in the landscape section—some of them rather uncommon, such as *giallo de' vasari* and *bruno d'Inghilterra*—are all described in Mariani's recipes (in the first section of the Leiden and Yale manuscripts). Cibo really did experiment with extracting colors from plants and fruits, as well as with mixtures of pigments, as similar proofs of the color samples described previously can be found throughout all Cibo's works, even in the margin of the text of the Rome manuscript. These *ricordi* (reminders) may have inspired Mariani to describe exactly those pigments and dyestuffs Cibo used. Interesting is the use of the name *giallo de' vasari* (potter's yellow) for lead-antimony yellow. In the Marche, the most important and famous majolica industry of Italy was flourishing in the sixteenth century. Cibo presumably obtained this pigment directly from the potters. In the recipe for *bruno de Inghilterra*, Mariani says the color was known to *spetiali et pittori* (pharmacists and painters) but that so far he had not been able to discover the exact composition. Most of the other recipes are traditional, except for those using plants and fruits to extract dyestuffs; the latter recipes may also come from Cibo. The extra chapters on composition and underdrawing, although not present in *Ricordi di belli colori*, seem to reflect Cibo's techniques when compared with his work.

Although no definite proof can be given, a personal exchange of information between Mariani and Cibo cannot be excluded.

A comparison between practice and theory is possible, as ample material can be researched. Not only Mariani's miniatures, especially the signed one, but also Cibo's many landscape drawings and the herbaria and illustrated Dioscorides editions, provide this opportunity. It is clear that Mariani used the same method of building up transparent layers in the background landscape of his signed miniature as is described in Cibo's instructions (Plate 8). Mariani's technique, although clearly guided by a personal interpretation, is very similar to that used in Cibo's landscape drawings executed in ink and colored with transparent watercolors.

The treatise is typical for the late sixteenth and early seventeenth century in describing the techniques for the execution of two extremely important genres of painting in that period: landscapes and miniature portraits. Both authors provide us with valuable information on the materials used, the techniques, and the studio practice, as well as the setting and the possible cooperation that provided the inspiration to write the treatise.

Appendix

Document 1. List of materials needed by the miniaturist, most described in the recipes in the first section of the treatise (Leiden, University Library, Voss. Ger. Gall. 5q. c.2v.):

Biacca, Cinabro, Minio, Biadetto chiaro e scuro, Azzurro oltrammarino, Azzurro grosso, Giallolino fino e sottile, Giallo santo, Terra negra, Terra rossa, Terra gialla, Terra d'ombra, Acqua verde, Tornasole, Terra gialla brugnata, Lacca di grana, Lacca di verzino, Verde di giglio paonazzo, Fuligine, Anaraccio, Negro fume, Negro d'osso di persico, Terra di campana, Orpimento, Terra verde o verde porro, Verd'azzurro e verdetto, Indico, Zaffarano, Verde rame orientale, Bol armenio o ocria lemmia, Sandracca, Bruno d'Inghilterra o color di sale, Sangue di drago, Acqua gialla di spino cervino, Marchesita arsa, Giallo de' vasari, Ocria, Ocria abrugiata, Acqua di verzino, Carbone, Acqua e aceto gommato e calcinato, Inchiostro, Liscia, Lapis rosso e negro, Piombino per disegnare.

Document 2. List of materials ordered by the supervisor Felice Antonio di Letiero for the workshops (Archivio di Stato, Florence, Fondo Urbino, Appendice, Filza 54, c.n.n.):

A dì 15 9bre 1607. [...] In per ordine di Maestro Felice Antonio di Letiero a dì 24 detto per li botteghini di S[ua] A[lt]tezza: Libra 2 1/2 Azzurro di Spagna fino [...]; Biadetto libre 4 [...]; Verdetto 3 1/2 [...] Giallolino di Fiandra libre 4 1/2 [...]; Verdetto libre 6 1/2 [...]; Azzurro di Spagna chiaro libre 4 oncie 3 [...]; Lacca di grana fina libre 2 [...]; Smaltino di Fiandra libre 10 1/2 [...]; Smaltine diverse con corpo libra 1 oncie 9 [...]; Penelli di sedoli con asta [...]; Penelli grossi di vano [...]; Penelli mezani [...]; Penelli piccoli [...]; Cocciole di madre perla no.100 [...]; Jacchino per portare detti robbe [...]. A dì 14 di Xbre 1607. Io Felice Antonio di Lettiero ho ricevuto li sopradetti robbe per servitio di botteghini di Sua Altezza. Umilmente Felice Antonio.

Document 3. Rome, Biblioteca Apostolica Vaticana, Urb. Lat. 1280, c.18v-19r.

Avertimenti sopra le mestiche.

Bisogna di avvertire che tutte le sorte de machie, tanto per arbori quanto per sassi e per greppi et prati, che è necessario di farle più oscure, o più chiare secondo la qualità del paese, anchora che tirino più al verde, o più al giallo, o più all'azzurro, o più al rossigno, o più al negro secondo che più piacerà, o secondo che ricercherà il disegno. La prima coperta non vol mai essere troppo chiara per potere dar poi i lumi secondo il bisogno, però sempre sarà bene mesticare con la prima machia quei colori che haveranno da sfoleggiare, poi illuminarle secondo si conviene e che satiffacci all'occhio et tanto si haverà da fare per prati, campi et sassi quanto per li arbori. Non si po far questo senza un po' de fatica et perdimento de' colori. Però chi vorrà fare che le cose passino secondo il dovere, bisognerà che componendo le mestiche vadi provando o sopra carte, o sopra tele, secondo dove si haverà da designare, et haver tanto di pazienza che si asciughi et parendole poi o troppo chiara o troppo scura, o troppo negra, o troppo azzurra, o troppo gialla, o troppo rosseggiante, potrà sempre rimediare con giungere più di quel colore che sarà necessario. Et sempre è bene far tanta mesticata che più presto possi avanzare che manchare, perchè non sola la persona se ne potrà servire ad ogni hora per quel disegno, ma perchè mancando haverà grandissima fatica de poterla rifare come fece la prima volta. Questo è più

necessario di fare che di haver lo esempio delle machie perchè si potrà fare qui una machia che volendola usar simile o sarà gran fatica farla dello istesso colore, overo sarà o troppo chiara o troppo scura o de altra qualità che non farà a proposito per il disegno. Sì che Vostro Signore se risolvi de' spigirirsi un poco et de esercitarse più spesso et così l esercizio passerà benissimo.

Acknowledgments

This research has been carried out with the financial support of The Netherlands Organization for Scientific research (NWO). I especially want to thank Tim Bedford for a critical reading and correction of the manuscript and for his encouragement.

Notes

1. From the results of linguistic research of the Leiden and Yale manuscripts, we may assume that both manuscripts are copies from the same, presumably original, manuscript. The handwriting as well as the paper quality and watermarks of the Leiden manuscript seem to point at an early date, possibly early or mid-seventeenth century. The Yale manuscript contains extra notes, some of them dated between 1614 and 1628, suggesting the early 1620s as the date of the copy. A complete edition of the treatise, with technical and art historical comments by the present author, is forthcoming.
2. Thieme, U., and F. Becker. 1930. *Algemeines Lexicon der bildende Künstler von der Antike bis der Gegenwart*, XXXI, Leipzig, 64–65. See also Zani, P. 1823. *Enciclopedia metodico-critico-ragionata delle belle arti*, part I, Vol. XIII. Parma, 44, 457, note 28.
3. Lancellotti, S. 1636. *L'Hoggià*. Venezia, 310.
4. Zuccolo Padrono, G. M. 1969. Miniature manieristiche nelle commissioni dogali del 11o cinquecento presso il Museo Correr. *Bollettino dei Musei Civici Veneziani* 72 (XIV):6, 16, note 6.
5. “Il giallo santo è un colore che si cava dal fiore della ginestrella, come m'insegnò un pittore a borgo in Brescia, mentre stava in qual luogo nel servizio del serenissima memoria del Duca Emanuele Filiberto di Savoia . . .” Leiden: University Library (Voss. Germ. Gall. 5q, fol. 16r)
6. For the will, see Pesaro, Biblioteca Oliveriana (MS 455), Spogli Almerici, fol. 338v. For Mariani's debt, see Florence, Archivio di Stato, Fondo Urbino, Classe III, Filza XXIV, fol. 242v.
7. Most documents are kept in the Archivio di Stato, Florence and the Biblioteca Oliveriana in Pesaro. See also Gronau, G. 1935. *Documenti Artistici Urbinati*. Firenze.
8. Biblioteca Oliveriana, Pesaro (MS Oliv. 1009) Cavaliere Domenico Bonamini, *Biografie degli Uomini Illustri Pesaresi*. fol. 290: “. . . l'ultimo Duca Francesco Maria che avendo prima risecate la grossa spesa del Duca Guidobaldo suo padre col far cessar tanti arti e celebri manufatte che qui si professavano, che vedendone in seguito il gravissimo derivo, si ricredette e comandò che si esigessero sotto la di lui corte, varie officine, alle quali deputò eccellentissimi maestri in ogni professione ed arti.”
9. These lists can be found in the Archivio di Stato, Florence, Fondo Urbino, Classe III, Filza XXIII (1581–1610 and 1613–1620), Classe I, Div. G., Filza CVI (1611–1612).
10. Archivio di Stato, Florence, Fondo Urbino, Classe III, Filza XXIII, fol. 474r: “Lista della famiglia e salariati di S.A.S. e provisioni dell'anno 1603: Maestro Propertio Griffi orologiaio, bocche 1; Maestro Cesare Maggiero pittore, bocche 2; Maestro Giovanni Fiamengo, bocche 2; Maestro Simuntio miniatore, bocche 2; Maestro Valerio miniatore, bocche 2; Maestro Nicolo argentiero, bocche 2; Maestro Boniforte orefici, bocche 2; Maestro Jacopo Cossa lavora d'ebano, bocche 2; Maestro Gervasio libaro. . .” The name of the artist and the number of people working in the workshop are mentioned: the artist, plus an assistant or apprentice, equals *bocche 2* (two mouths).
11. Archivio di Stato, Florence, Fondo Urbino, Appendice, filza 48, not numbered. In this document the decoration of some rooms on the first floor of the palace is described: “Dalla porta che entra nella galleria nuova alla porta che va alle botteghe. . .”
12. Archivio di Stato, Florence, Fondo Urbino, Appendice, Filza 32: fol. 13r a.f.
13. The letters from Falcucci to the duke concerning the search for a miniaturist can be found in the Archivio di Stato, Florence, Fondo Urbino, Classe I, Div. G,

- Filza CXLIII, fols. 1122r, 1125v, 1129v, 1133r; and Biblioteca Oliveriana, Pesaro (MS 375), vol. XXIV, fols. 227v, 212r, 207r, 179r. On the miniaturists, see also Meloni Trkulja, S. 1981. I miniatori di Francesco Maria II della Rovere. In *Omaggio ai Della Rovere*, ed. P. Dal Poggetto. Pesaro.
14. Michelini-Tocci, L. 1965. *Il Dante Urbinate della Biblioteca Vaticana*. Facsimile. Milano.
 15. Meloni Trkulja, op. cit. (note 13). From the same author: 1980. *Firenze e la Toscana dei Medici nell'europa del Cinquecento*, vol. Palazzo Vecchio: committenza e collezionismo medicei, Florence: 200–205. See for more information on Mariani and his miniatures: Hermens, E. 1993. Valerio Mariani da Pesaro: a seventeenth-century Italian miniaturist and his treatise. *Miniatura* (3/4):80–93.
 16. See Hermens, E. 1993. Valerio Mariani da Pesaro and his treatise: theory and practice. *Technologia Artis* (3):109–12. The infrared research was executed by E. Buzzegoli and D. Kunzelman, Laboratorio di Restauro, Uffizi, Florence.
 17. Lancellotti, op. cit., 310. “Valerio Mariani di Urbino fu suo discepolo e avanzò il maestro di pazienza e delle sue miniature ebbero i maggiori Precipi del mondo. . . . Havevano un degreto di macinar l’oro alla Persiana per miniare e per iscrivere, che stava saldo come l’antico.”
 18. Tongiorgi Tomasi, L. 1989. Gherardo Cibo: Visions of landscape and the botanical sciences in a sixteenth-century artist. *Journal of Garden History* 9 (4):208.
 19. Thieme and Becker, op. cit., XIII, 240. See also Bertolotti, A. 1880. *Artisti Belgi ed Olandesi*, Roma, 41–4. See also Hoogewerff, G. I. 1912. *Nederlandsche schilders in Italië in de XIVe eeuw*, Utrecht, 142–43.
 20. Nesselrath, A., 1989. Gherardo Cibo: “qui non è cognito.” In *Gherardo Cibo alias “Ulisse Severino da Cingoli,”* ed. A. Nesselrath. Comune di San Severino Marche, 5–36.
 21. Celani, E. 1902. Sopra un erbario di Gherardo Cibo conservato nella R. Biblioteca Angelica di Roma. *Malphigia* XVI:10.
 22. British Library, London, (MS Add 22333 and 22332). See Tongiorgi, op. cit.
 23. Cibo’s letter can be found in the Archivio di Stato, Florence, Fondo Urbino, Classe I, div.G, Filza CCLX, fol. 6r. For the edition of Dioscorides, see Nesselrath, op. cit., catalogue no. 20, 100. Roma, Biblioteca Alessandrina (inv. Rari 278).
 24. Idem, catalogue no.40:123–27. Jesi, Biblioteca Comunale, Album A: “Qui dentro sta un paesetto in carta reale, de mano del pittor[e] Fiamengo ch[e] serve il n[ostro] Duca Sereniss[im]o di Urbino: che mi mano il S[ignor]e Cavalier Ardoino. Di Aprile mi pare. 1591. E chiamase M Giovanne.” He also mentions drawings “quelli de mano d[e]l pittor[e] da Forli. . . .”
 25. Thieme and Becker, op. cit., II, 78, under the name Girolamo Arduini. See also Zani op.cit. (note 3), II, 181, 320, note 138. Arduini is said to have written a treatise titled *Trattato del modo di piantare e fortificare una città*.

Abstract

The problems of interpretation of written sources on painting technique are well known. Through loss of the technical tradition, within which details of information were well understood at the time of writing, technical information is obscured for later generations. In courses on historical techniques of painting at the School of Conservation in Copenhagen, attempts at reconstructing the kind of gesso ground used in early Italian painting have prompted investigation into the actual meaning of the “giesso uolteriano” mentioned by Cennino Cennini in his treatise. This paper examines the problem from three angles: (1) the possible meanings of Cennini’s text on this point; (2) the preparation of gesso grounds from the possible forms of gesso resulting from the first point (dihydrate, hemihydrate, anhydrite); and (3) technical evaluation of the reconstructions and comparison with the results of scientific examination of grounds in early Italian painting.

Questions about Medieval Gesso Grounds

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Introduction

The problems in interpreting written sources on painting techniques are well known. Besides the paintings themselves, the written sources are the only testimony of materials and techniques used in former times. Advanced methods of scientific analysis employed in the examination of paintings do not always answer questions about materials and techniques. And the written sources do not always provide easy access to painting techniques. Time has obscured the comprehension of the texts. The pure linguistic translation of a written source is often far from sufficient, but may be greatly aided by reconstructing the technical details described and comparing the results of the scientific analyses.

Understanding Cennini’s text

During the courses in historical techniques of painting at the School of Conservation in Copenhagen, it was increasingly dissatisfying for the author and others to reconstruct the gesso grounds as described by Cennino Cennini, and it was eventually necessary to scrutinize his text concerning grounds. Merely reading Cennini’s instructions in the English translation by D. V. Thompson in 1933 was not sufficient; it was obvious that things were not as easy as they may have seemed (1). Not that Cennini is imprecise in his instructions on this point; he is more thorough in his instructions on ground than in his description of paint application. But how can certain important passages be interpreted 600 years later?

The original manuscript by Cennini being lost, the question of which surviving copy to use as a source remains, of course, a central one. That aspect will not be addressed in this article; the source used here is Lindberg’s Swedish version of Cennini’s *Codex Laurentianus*. Lindberg’s translation shows semantic details, absent in previous translations, that are important for the understanding of decisive technical details (2).

In Chapter CXV of his treatise, for example, Cennini describes the preparation of the ground for painting on panel. Painting in the Middle Ages included gilding. Gilding was the main reason for the great efforts invested in creating a perfect ground. Gypsum was the material used in the preparations of grounds for painting and gilding throughout the whole Mediterranean area as far back as the first millennium B.C.E. (3). The first written evidence of a ground for painting made of gypsum appears in the ninth-century Lucca manuscript, which mentions a ground consisting of gypsum and glue for gilding on wood (4). Cennini clearly distinguishes between *gesso grosso* and *gesso sottile*; that is, a double-structured ground consisting of several layers of a coarse ground on top of which are applied several layers of a finer ground. In both structures, the medium is animal glue (5). Such grounds, with local variations, were found in fourteenth- and fifteenth-century paintings from Florence and Siena (6).

Lindberg’s translation, here translated from Swedish into English by the author (7), differs in several crucial passages from the 1933 English translation by D. V. Thompson. The passage concerned is the following: The Italian text says, “poi abbi giesso grosso cioe uolteriano che e purghato ede tamigiato amodo di farina, . . .” which Thompson translates as, “then take some gesso grosso,

that is, plaster of Paris, which has been purified and sifted like flour” (8, 9). The Swedish translation says: “Tag sedan grovgips, det vill säga Volterra-gips, som er renad och siktad som mjöl. . . .” [Then take coarse gypsum, that is to say Volterra gypsum that has been purified and sifted like flour. . . .]

The question is, apart from the obvious fact that the gypsum mentioned was mined in the quarries at Volterra, what was then understood by this statement? Initial attempts by the author at reconstructions were based on Thompson’s translation. The use of his “plaster of Paris,” a gypsum burned to the hemihydrate form, resulted in immediate setting in water (10).

The next chapter, which describes the preparation of the gesso sottile, reveals details about the *gesso volteriano* not mentioned in Chapter CXV. Chapter CXVI says, “Ora si uuole chettu abbi dun giesso elquale sichiama giesso sottile elquale e di questo medesimo giesso mae purghato perbene unmesse tenuto in molle innun mastello rinuoua ogni di laqua chesquasi siinarsiscie edesciene fuori ogni fochor di fuocho e uiene morbido chome seta. . . .” (11). In Lindberg’s translation: “Nu vill man att du skall ha en gips som man kallar fingips, vilken består av denna samma gips, men den är renad i gott och väl en månad, lagd i blöt i en balja. Byt varje dag vattnet tills den är nästan torr, och varje glöd av eld går ut den, och den blir mjuk som silke. . . .” [Now you should have a gesso, which is called fine gesso, which is this same gesso, but it has been purified for a good month, soaked in a basin. Change the water every day until it is almost dry, and every glow of fire leaves it, and it will be soft as silk. . . .]

There are two things to be noticed here: Lindberg argues that the remark about the glow of fire leaving the gypsum—the same gypsum that was used for the gesso grosso—can only be understood in the sense that the gypsum was indeed burned. The question is, what form resulted from the process? The remark about the soaking in water constitutes another important point: What kind of procedure is meant? The existing translations are not very clear about this point. It seems quite conceivable that a double purpose—a washing process and a process of changing the morphology and chemical composition of the material—was served by this treatment.

The preparation of gesso grounds

The naturally occurring gypsum, calcium sulfate dihydrate $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, can be burned at various temperatures. Burning at 128 °C produces $\text{CaSO}_4 \cdot \text{H}_2\text{O}$, the hemihydrate form. Burning at 130–160 °C creates an anhydrite and hemihydrate mixture (12). This is the so-called plaster of Paris or stucco plaster, which sets quickly with water and thus returns to the dihydrate form. Between 163 °C and 300 °C, soluble anhydrite, CaSO_4 , is formed, which also reacts quickly with water. According to Mora, et al., the dihydrate form will, at temperatures above 250 °C, turn into insoluble anhydrite that is no longer able to set with water (13). Experiments at the School of Conservation have shown, however, that anhydrite burned at 300 °C, 400 °C, and even 500 °C is still able to react with water, forming dihydrate again (Figs.1, 2) (14). *The Merck Index* even gives 650 °C as the limit above which the insoluble anhydrite is formed (15). Above 900 °C, the so-called Estrich gypsum (a combination of anhydrite and calcium oxide) is formed; this material sets very slowly with water and becomes extremely hard. Gypsum can also occur in nature as insoluble anhydrite, CaSO_4 .

In Cennini’s time, the mined gypsum was burned in rather primitive kilns. Gettens describes a very ancient kiln with little temperature control, in which blocks of gypsum are stacked and a fire lighted at the base of the kiln (16). The result of this process must have been a mixture of anhydrite, hemihydrate, and even dihydrate forms. Overburned or dead-burned insoluble anhydrite lumps must have been prevalent at the bottom of the stack near the source of heat. In the upper tiers, the lumps burned at lower temperatures, hemihydrate/anhydrite forms must have been present in larger relative amounts.

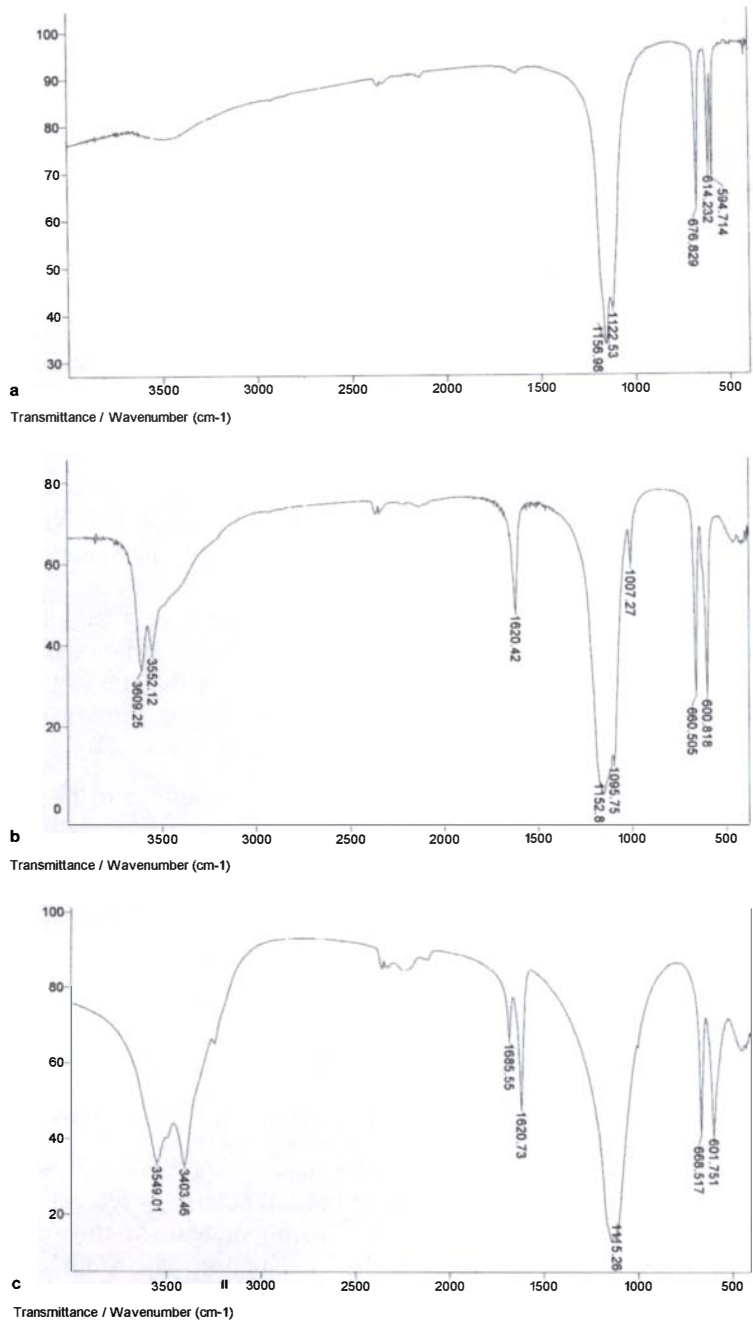


Figure 1. Fourier transform infrared spectra of calcium sulfate with different amounts of crystal water: (a) anhydrite; (b) hemihydrate, dihydrate baked at 135 °C for two hours; (c) dihydrate.

It is even possible, as suggested by Gettens and Mrose, that if the lumps were fairly large, that the outside would have been burned to anhydrite while the inside would be only partially dehydrated (17). Some of the inside of the gypsum lumps in the primitive kiln stack could have been heated below 100 °C so that the gypsum remained hydrated. It is interesting to note here that Theophilus gives the following instructions: “. . . take some gypsum burned in the fashion of lime . . .” which must be understood to have been burned at very high temperatures, that is, above 900 °C (18). The resulting substance will be quicklime (calcium oxide), which is slaked in water and transformed into lime (calcium hydroxide).

Gettens describes another kind of kiln that worked in the same way as ancient bread-baking ovens; after a fire had preheated the inside of the brick oven until the interior was red hot, the fire was extinguished, the coals removed, and the bread—or, in this case, lumps of gypsum—were placed in the oven overnight. This kind of operation allowed for a more uniform heating. This

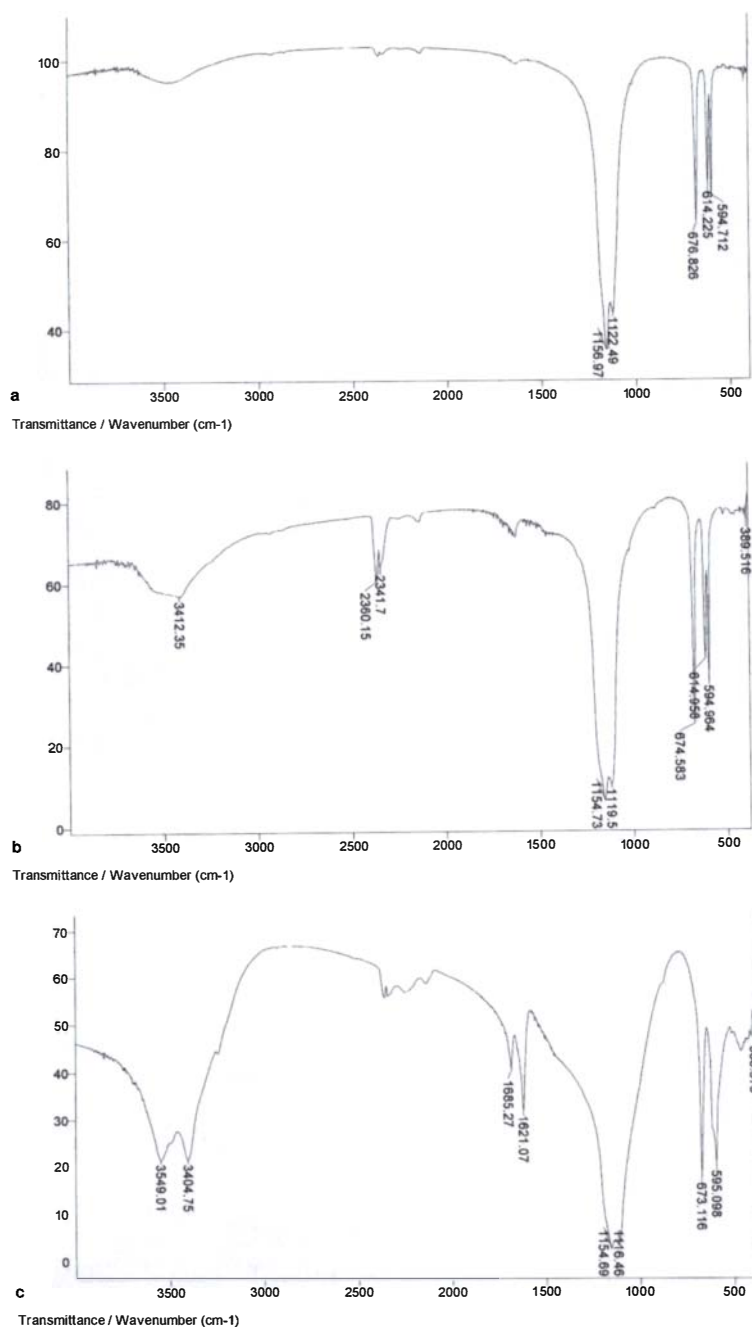


Figure 2. Fourier transform infrared spectra of gypsum burned at 500 °C: (a) anhydrite sample before treatment with water; (b) slurred in water for two days, the sample still consists of anhydrite; (c) slurred with water for ten days, the sample now consists of dihydrate.

kind of oven had been in use in the Mediterranean civilizations since early Roman times (19). The painter's manual of Mount Athos actually describes the baking of gypsum in a similar type of kiln (20). This manual suggests that the product from the burning process would be soluble anhydrite, which, soaked in water, would form the dihydrate product again.

In Cennini's directions for the preparation of the gesso sottile, the burnt gypsum should be soaked in water for about a month. Lindberg states that Thompson's translation of the word *rinuoua* as "stir up," referring to stirring the water every day, is not correct. Thompson may have mistaken the "n" for "m" (21). *Rinuoua* literally means renew or change. Lindberg further argues that *siinarsiscie* means "to dry," dismissing Thompson's translation of "rots away" as incorrect. Lindberg offers the following interpretation: the water should be poured off the soaked gesso every day until the gesso is almost dry, which simply means that as much water as possible should be

poured off each time; such a process is actually a washing process. Water-soluble impurities, such as salts, possibly present in the gypsum would be washed away in this process. Such impurities might cause discoloration of the ground or efflorescence of salts from it. Apart from this, soaking the burned gypsum in water obviously also had the function of changing the texture and the chemical composition of the material, supposing the point of departure is soluble anhydrite.

Technical evaluation and comparison of results

The recent examination of grounds in Italian paintings by the Laboratoire de Recherches des Musées de France elaborates on the double structure of the Italian gesso grounds (22). This double structure was also shown in the examinations by the National Gallery's laboratories in London (23). Unfortunately, this point was not addressed in the otherwise excellent 1954 examination by Gettens and Mrose, which makes their results of somewhat limited value in this context.

Concluding from the results of examinations of grounds, the gesso grosso consists of mainly anhydrite, sometimes with dihydrate present. I am here referring to the French examination, which even states the ratio of anhydrite to dihydrate (24). The numerous Florentine and Sienese examples show the following compositions for the gesso grosso: 100% anhydrite or 75:25 anhydrite:dihydrate or 50:50 anhydrite:dihydrate. For the gesso sottile, two ratios: 100% dihydrate or dihydrate containing 25% anhydrite.

Considering the chemical changes of soluble anhydrite in contact with water (the binding medium of the ground is animal glue, which always contains a certain amount of water), it seems puzzling that the gypsum in the layers of gesso grosso kept its anhydrous form. A possible explanation could be that the conversion process became slower as the burning temperature increased (25). As the anhydrite did not change into dihydrate, the evaporation time of the water in the binding medium must have been shorter than the hydration time of the anhydrite. It would be extremely improbable that the gesso grosso material would be a stable anhydrite, which is not able to react with water, or a dead-burned anhydrite, which is neither form, because the examples concerned show the double-structured grounds of gesso grosso and gesso sottile. It would be very unlikely that two different kinds of gypsum would be employed in the process. The analyses of the sottile layers show dihydrate, which is the soluble anhydrite soaked in water. It must be assumed that the point of departure in both the grosso and the sottile is the same compound: soluble anhydrite. The presence in the gesso grosso layers of a mixture of anhydrite and dihydrate would be explained by the sometimes poorly controlled burning process.

In the samples from Umbria, Latium, the Marches, Venice, and Ferrara showing single-structured grounds, the dihydrate present (100%) is claimed to be the natural unburned dihydrate (26). The raw gypsum (calcium sulfate dihydrate) does not differ either in chemical composition or crystal structure from a dihydrate that has gone through the process applied to a gesso sottile of burning and soaking in water (27).

The question remains, is it possible that the dihydrate present in the examples mentioned above could be the processed dihydrate? The author's reconstructions indicate that the raw calcium sulfate dihydrate can only with great difficulty be triturated to a degree that will make it usable as a ground. Even then, the resulting surface will not facilitate a satisfactory base for gilding. It must be admitted, however, that raw gypsum can vary considerably with regard to texture (28). Considering this, we can exclude the possibility that raw gypsum could have been pulverized to yield a satisfactory product. It seems likely that in most cases the process would be greatly facilitated by first burning the calcium sulfate to an anhydrite, followed by grinding and processing with a final soak in water to produce the dihydrate form. This is the

process described by Cennini for gesso sottile as furnishing the best ground for gilding (29). In fact, Cennini describes in Chapter CXVIII how certain panels can be grounded only with gesso sottile.

Conclusion

Finally, returning to the meaning of the gesso volteriano in Cennini's text, we presume that the material must have been calcium sulfate dihydrate burned at 300–650 °C, thus forming soluble anhydrite, which was used for the gesso grosso. The preparation of the gesso sottile would be a process of changing the chemical composition, altering the texture, and washing.

The author does not agree with the point of view put forward by E. Martin, et al. that Cennini did not know whether the gesso volteriano he discussed was unburned gypsum directly from the quarries of Volterra or if it was processed by being burned (30). Cennini must have had a good understanding of these materials. That we do not understand the exact meaning of his words 600 years later is another matter. In his own time and geographical sphere, it was most likely very well understood, at least by other craftsmen.

Acknowledgments

It was extremely difficult to obtain raw calcium sulfate dihydrate in Denmark. I am very much indebted to the following persons who made the practical experiments possible: V. Meyer (Building Materials, Kalkbrænderihavngade 20, 2100 Copenhagen), who readily took the trouble to import unburned gypsum for my research purposes, and to Niels Erik Jensen (CTO, Ålborg Portland, 9220 Ålborg Øst), who demonstrated a keen interest and readiness to help with this project by providing me with raw gypsum in various forms. I wish to thank my colleague, chemist Mads Chr. Christensen (School of Conservation, Copenhagen) for his help in carrying out the analyses, and for fruitful discussions. My colleague, geologist Nicoline Kalsbeek, (School of Conservation), has kindly furnished me with information from the Cambridge Structural Database. Finally, I wish to thank Professor Bo Ossian Lindberg (Institutionen för Konstvetenskap, University of Lund, Sweden) for reading and commenting on the text.

Notes

1. Cennini, C. 1960. *The Craftsman's Handbook: Il libro dell'arte*. Translated by D. V. Thompson, Jr.. New York, Dover Reprint (Yale University Press, 1933).
2. Cennini, C. *Boken om målarkonsten. Översättning och notkommentar av Ossian Lindberg*. Unpublished manuscript provided by Professor Lindberg. Part of the text has been published in Lindberg, B. O. 1991. *Antologi om måleriteknik*. Lund: Institutionen för Konstvetenskap, Lunds Universitet. As shown by Lindberg, the *Codex Laurentianus* (Florence, Biblioteca Laurentiana, MS 78 P. 23) must be considered closest to the lost original manuscript. The *Codex Riccardianus* (Florence, Biblioteca Riccardiana, MS 2190), however, is our only source for several passages which are missing in the Laurentianus text. Therefore, Lindberg based his edition on both the Laurentianus and the Riccardianus codices, as Thompson also did. For the discussion of the surviving transcripts of Cennini's text and the various editions and translations, see Lindberg, B. O. 1991. Cennino Cennini: den okände mästaren. In *Målningens anatomi*. Exhibition catalogue. Kulturen, Lund, 39–48.
3. Oddy, W. A. 1981. Gilding through the ages: An outline history of the process in the Old World. *Gold Bulletin and Gold Patent Digest* (14): 75–79, in particular page 77. See also, Gilded wood: conservation and history. 1991. *Gilding Conservation Symposium, Philadelphia Museum of Art*. Madison, Sound View Press, 34.
4. Berger, E. 1973. *Quellen und Technik der Fresko-, Oel- und Temperamalerei des Mittelalters*. Liechtenstein Sändig reprint (Munich 1912), 13.
5. The medieval sources mentioning the preparation of grounds also mention (animal) glue as the medium. The only exception, to my knowledge, is the fifteenth-century Bolognese manuscript, which mentions a ground that apparently has no medium but depends on the setting with water of the hemihydrate. See Merrifield, M. P. 1849. *Segreti per colori, Original treatises on the arts of painting*, Vol. II. London, John Murray, 595.
6. Martin, E., N. Sonoda, and A. R. Duval. 1992. Contribution à l'étude des préparations blanches des tableaux italiens sur bois. *Studies in Conservation* (37): 82–

92. The fifty paintings examined by the authors reveal a clear trend. Paintings belonging to the Florentine and Sienese schools showed double-structured grounds of gesso grosso and gesso sottile, identified respectively as anhydrite and dihydrate. Venetian examples showed a tendency towards single-structured grounds consisting only of dihydrate, as also observed in Gettens, R. E. and M. E. Mrose. 1954. Calcium sulphate minerals in the grounds of Italian paintings. *Studies in Conservation* (1):174–90. See in particular pages 180–83. The recent French examination finds that the examined paintings representing schools outside Tuscany are not numerous enough in their material to conclude anything general about the treatment of grounds in the rest of Italy.
7. See note 2.
 8. The wording of the *Codex Laurentianus* is quoted from Lindberg, B. O. 1990. Feta och magra limmer enligt Cennino Cennini. In *Meddelelser om Konservering*, 165–87. Lindberg notes that the *Codex Riccardianus* in this passage has a slightly different, but not clearer wording than the Laurentianus. Lindberg points to the fact that the manuscript lacks interior punctuation.
 9. Cennini, 1960. Op. cit., 70.
 10. Unfortunately, this suggestion by Thompson, which in the author's opinion is wrong, is apparently reflected in numerous texts on medieval grounds. See, for instance, Straub, R. E. 1984. Tafel- und Tüchleinmalerei des Mittelalters. In *Reclams Handbuch der künstlerischen Techniken*, Vol. I. Stuttgart Philipp Reclam, 156–57.
 11. See note 8.
 12. The various sources on gypsum are obviously not identical in their information on the relationship between the chemical composition of the gypsum and burning temperatures. *Römpps Chemielexicon*. 1979. Stuttgart, 575–76. See also, Mora, L., P. Mora, and P. Philippot. 1984. *The Conservation of Wallpaintings*. London, Butterworth, 39–47. Also see *The Merck Index*, 9th ed. 1976, 1707.
 13. Mora, et al., op. cit. (note 12), 42.
 14. Lindberg, B. O., and B. Skans, in their experiments carried out at Institutionen för Konstvetenskap i Lund, have also observed that gypsum burned at 300 °C for two hours is still able to react with water. Lindberg, B. O., and B. Skans. 1990. Feta och magra limmar enligt Cennino. In *Meddelelser om konservering*, 184.
 15. See note 12.
 16. Gettens, R. J. 1954. A visit to an ancient gypsum quarry in Tuscany. *Studies in Conservation* (1):4, 190–92.
 17. Gettens and Mrose, 1954. Op. cit., (note 6), 185.
 18. *Theophilus on Divers Arts*. 1979. Translated by G. Hawthorne and C. S. Smith. New York, Dover Reprints, 27.
 19. *A History of Technology*, Vol. II. 1957. Oxford, The Clarendon Press, 118.
 20. *The Painter's Manual of Dionysius of Fournia*. 1978. Translated by P. Hetherington. London, 6. It appears from the directions in the Athos book, that right from the mining, it is important to choose the right kind of gypsum: “. . . see that you use only what is white and glistening.”
 21. Lindberg, 1990. Op. cit. (note 8), 184.
 22. See note 6.
 23. Bomford, D., J. Dunkerton, D. Gordon, A. Roy, and J. Kirby. 1990. *Art in the Making*. London, National Gallery. See in particular pages 17–19.
 24. Martin, Sonoda, and Duval, 1992. Op. cit., 86–89, Table 2.
 25. It must, of course, be below 650 °C, which is the limit beyond which the anhydrite is no longer able to react with water.
 26. Martin, Sonoda, and Duval, 1992. Op. cit., 90. See also Dunkerton, J., and A. Roy. 1986. The Technique and Restoration on Cima's *The Incredulity of S. Thomas*. *National Gallery Technical Bulletin* (10):4–27, especially page 5. See also Dunkerton, J., A. Roy, and A. Smith, A. 1987. The unmasking of Tura's "allegorical figure": A painting and its concealed image. *National Gallery Technical Bulletin* (11):5–35, especially 19.
 27. If a different crystal structure had existed for the dihydrate it would most likely have been included in the CSD (Cambridge Structural Database). This is not the case.
 28. It was quite obvious that not only was the burned gypsum (the anhydrite) much easier to grind than the raw gypsum, but the anhydrite burned at 700 °C was much easier to grind than the anhydrite burned at 400 °C.
 29. Cennini, 1960. Op. cit., 73.
 30. Martin, Sonoda, and Duval, 1992. Op. cit., 90

Abstract

The frequent use of verdigris in paintings from the early Gothic period to the eighteenth century is reflected by the citation of the pigment in treatises. The many warnings against the use of verdigris and precautions recommended to prevent it from discoloring are set against the fact that verdigris and copper resinate have survived in many cases as an intensely green color. It is suggested that the method of preparation, dissolving verdigris in warm oil, and its application with a piece of canvas contribute to the stability of the green glaze. Colored underpainting and yellow glazes on top of the green layer were used to modify the green tone.

Aspects of Painting Technique in the Use of Verdigris and Copper Resinate

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Introduction

Verdigris and copper resinate have been found in paintings dating from medieval times to well into the eighteenth century. Among the green substances available for painting, verdigris had the most intense color but little covering power compared with malachite. Verdigris was made by exposing strips of copper to vinegar vapor as described by Theophilus at the beginning of the twelfth century (1). Many later treatises and artists' handbooks contain recipes on how to make verdigris, how to distill it by dissolving the material in vinegar and allowing it to recrystallize, and how to turn it into the transparent green color that today is called copper resinate.

The use of verdigris

Verdigris was used ground in oil, in cherry gum, and also in egg, but it had a bad reputation for turning brown or black. Cennino Cennini, at the end of the fourteenth century, wrote that "it is nice to the eye but it does not last," and in the fifteenth-century Strasburg Manuscript, a note states that verdigris does not agree with orpiment (2, 3). Leonardo da Vinci wrote at the end of the fifteenth century that the beauty of verdigris "vanishes into thin air if it is not varnished immediately" (4). The warnings become even clearer in the Brussels Manuscript, written by Pierre Lebrun in 1635: "Verdigris is added to charcoal black, or lamp black, to make these colours dry, but it is used only with the shadows, for it is a poison in painting, and it kills all the colours with which it is mixed" (5). At the same time, between 1620 and 1640, De Mayerne in London wrote in his notebook (6):

Le verd de gris, which is only used for glazing, is an enemy of all colours, so much so, that it kills them all, especially azurite. Even if you work with a brush that has been cleaned with oil that has come into contact with verdigris before, as clean as it may seem, or if you put the colours on a palette on which there has been verdigris before, it spoils everything. In this way, he who wishes to work with verdigris has to keep brushes, palette and oil for cleaning separate.

In 1757 Pernety wrote disdainfully, "Ver de gris: this is poisonous for all animals as well as for colours; if one wants to make use of it in oil painting, one has to use it on its own or at most mixed with black. It ruins all the colours, and even if there was only a little bit in the grain of the canvas it would spoil all the colours that were laid on it in the process of painting" (7).

Chemical analysis, however, has shown that the beautiful greens and green glazes that have survived in paintings are indeed very often verdigris and copper resinate. Numerous reports published in the *National Gallery Technical Bulletin* and in the *Bulletin de l'Institut Royal du Patrimoine Artistique* bear witness to this fact. In his investigation of verdigris and copper resinate, Hermann Kühn came to the conclusion that "experiments with paint specimens and observations on paintings . . . show that the properties of verdigris are not nearly as harmful as suggested by the literature" (8).

Why have some green paint layers of verdigris and copper resinate turned brown while others remained intact? After a search through the treatises for instructions on how to use this dangerous green pigment and a comparison of the written instructions with the actual methods of applying the pigment on the paintings, results seemed to suggest that three interesting factors determine appearance: (1) verdigris has to be thoroughly embedded in oil or an oil-resin varnish to be protected from air and humidity; (2) colored underlayers contribute to the beauty of the green glaze; and (3) admixtures of yellow lakes or yellow glazes on top of the transparent green layer were applied to soften the sharpness of the bluish-green tone of verdigris and copper resinate.

The instructions for the use of verdigris emphasize that it should be thoroughly incorporated into the medium and covered with varnish as soon as possible. The early use of verdigris for *pictura translucida* on gold leaf and tinfoil described by Theophilus, Cennini, and in the Tegernsee Manuscript (ca. 1500) points to this fact (9, 10, 11). The Strasburg Manuscript simply states that all colors should be ground in oil. It proceeds to explain how to mix colors and how to achieve good results by painting in several layers, the painting technique generally found in fifteenth-century paintings (12).

In *On the true precepts of the art of painting* (1587), Armenini gives very detailed instructions on painting technique, particularly on how to paint green drapery (13):

If the drape is to be green, one does as follows: After the sketch is made using somewhat coarse green, black and white, it is lightly painted with a mixture of verdigris, a little common varnish, and some giallo santo. With a coarse brush of miniver, one veils the sketch uniformly; next one pats it either with the palm of the hand or with a little wad of cotton wool covered with linen, until the given colour is uniform and no brush strokes can be detected. And if the result is not to one's satisfaction, after the veiling is dry one repaints with the same mixture and then pats in the prescribed way.

He also explains that before veiling, the thoroughly dried sketch has to be oiled out very thinly to stop the glaze from being repelled by the underlayer. A painting by Palmezzano depicting the *Mystic Marriage of Saint Catherine*, signed and dated 1537, shows exactly this technique in the green drapery of the throne and St. Catherine's green garment (Plate 9). The pattern of the textile used for dabbing on the glaze is clearly visible (Plate 10). The build-up shown in the cross section also corresponds to Armenini's instructions (Plate 11); even the oiling-out layer is visible in ultraviolet light (Plate 12). The glaze was apparently too viscous to be spread out evenly with a brush, therefore the glaze was spread by dabbing it with a rag. Traces of textile pattern are also visible in a Flemish altarpiece, painted in Antwerp around 1520, now at Oxburgh Hall in Norfolk. In the process of dabbing on the green glaze the artist could not always keep within the outline of his green drapery, so he had to retouch the background in some places. Minor overlaps were simply left; one can see the weave pattern of the rag, the glaze is partly discolored and some green particles are still visible.

Experimentation

As an experiment, some neutral recrystallized verdigris was ground in linseed oil and the mixture was heated very gently to approximately 50 °C, until the copper acetate had dissolved and the pigment grain had disappeared. The mixture was intensely green and quite viscous. It could be spread with a brush while warm, but congealed very quickly, making the brush strokes very coarse and imprecise. However, it was quite easy to spread the glaze by dabbing it on with a piece of canvas. After a few hours, the glaze dried. Within a few days the thick brush strokes of green glaze showed drying wrinkles, whereas the dabbed area looked the same as when it was applied, demon-

strating that spreading this glaze thinly in several layers is not merely a matter of style but also a technical necessity.

The green tablecloth in Jan Davidsz de Heem's *Still Life with Fruit* (Cambridge, Fitzwilliam Museum), painted in 1650, consists of a green glaze over a dark brown underlayer with yellow-green highlights. Clearly this green glaze has been applied with a brush, as the fairly clumsy brush marks are visible. Along the contours of the vine leaves and on either side of the thin stalks of the cherries, the green glaze leaves a gap showing the dark brown underlayer. It is quite clear that this glaze must have been a rather viscous liquid and therefore difficult to paint out with any precision.

The recipes for making copper resinate, collected by the doctor Theodore Turquet de Mayerne in London between 1620 and 1640, are generally considered to be the earliest. They call for verdigris to be heated with Venetian turpentine and oil of turpentine as follows: "Beautiful green: take 2 ounces of Venetian turpentine, 1 1/2 ounce of oil of turpentine, mix and add 2 ounces of verdigris in little pieces. Set it on hot ashes and let it boil gently. Try it on some glass to see if you like the colour; strain it through a cloth" (14).

Trying out the recipe, it was found that the verdigris did not dissolve in the mixture of Venetian turpentine and oil of turpentine because there was not enough resin present; also, the presence of oil of turpentine hampered the reaction of the copper acetate with the Venetian turpentine. When more resin in the form of rosin was added, a dark green resinous substance resulted, which was liquid while hot, but hard and glassy as it cooled. This green glassy substance can be ground in oil like a pigment. When ground in oil, however, the color is no longer very intense.

Another recipe in the De Mayerne manuscript asks for verdigris, ground in oil, to which hot common varnish is added: "Painters, i.e. those who paint as well as those who paint furniture and blinds, grind verdigris with linseed oil and then add common varnish, stirring it well. They allow the impurities to sink down and only use the clear liquid, which they apply warm" (15). With the term "common varnish" a solution of resins in oil is meant. This recipe was the base for the experiment described above, grinding verdigris in oil and heating it.

The preparation and application of the green glaze is not the only secret of de Heem's tablecloth: the dark reddish-brown undermodeling gives the green glaze its velvety depth. This observation proved to be very useful during retouching. The only way to match this intense dark green color was to reconstruct the build-up of layers exactly. The verdigris in the green glaze was substituted with the transparent green pigment viridian (because of its stability) and a little synthetic Indian yellow to match the required tone.

The reason a green glaze over a reddish-brown underlayer appears so very dark lies in the absorption of the waves of the spectrum: green absorbs all red waves, red absorbs all green waves. The two layers superimposed absorb practically the entire spectrum of visible light, so that the resulting color is almost black.

The painter's use of green glazes and grisaille

The green curtain in Titian's *Tarquin and Lucretia* (Fitzwilliam Museum) shows green glazes over an undermodeling in red with broad white highlights. The idea is ingenious. To start with, Titian underpainted the curtain in gray with some azurite, then he laid in the modeling with a brownish red containing some red lake and some very generous white highlights. As he applied the green glaze, the shadows in the folds appeared very dark green, the middle tones were light green because of the green glaze over white brush strokes, and the flickering highlights remained white from the undermodeling, partly emphasized with an extra brush stroke. In some places, Titian allowed the red to shine through, giving the material a wonderful shot-silk effect.

In late Gothic painting, grisaille underpainting was fairly common for green garments or landscape elements. This was found in paintings by van Eyck as well as by Uccello, north of the Alps as well as in Italy (16, 17). The method is described in artists' treatises. Palomino, in the first quarter of the eighteenth century, describes the method of underpainting green cloths with grisaille (18). The same instructions are found in Crocker's treatise, published in 1743 (19). This documents a long tradition. Grisaille undermodeling was not the only method recommended. In his *Portrait of a Dominican Monk* (Upton House near Banbury), painted around 1525, Lorenzo Lotto used undermodeling in azurite and lead white with the darkest shadows painted in an olive green mixture of black and lead-tin yellow. The next layer contains verdigris with very little lead-tin yellow and some black in the shadows, followed by a green glaze. This green glaze is a substantial, absolutely homogenous layer, without any visible brushwork or textile pattern.

In addition to colored undermodeling to modify the green glaze, there is the possibility of adjusting the green color by means of yellow glazes. Cennini recommended saffron for this purpose (20). Leonardo suggested aloe dissolved in warm spirit of wine: "If you have finished a painting with this simple green [verdigris in oil] and if then you were to glaze it lightly with this aloe dissolved in spirit of wine, then it would be of a most beautiful colour. Also this aloe can be ground in oil, either on its own or together with the copper green and with any other colour you like" (21).

De Mayerne noted a recipe for a green copper glaze that called for some *terra merita*, which is *curcuma*, to be added to improve the color (22). Goetghebeur and Kockaert drew attention to the existence of yellow and brown glazes on top of layers of verdigris or copper resinate (23). In cleaning green areas in paintings, therefore, it is not sufficient to test a brown layer for copper to find out whether the paint is discolored copper resinate. Even if it is not, it can still be an original yellow lake, now discolored. As these organic lakes are very difficult to identify, their presence is often suspected without reassuring proof either way, a most disconcerting situation for the restorer. In addition to research by means of scientific analysis, it might be helpful to approach the problem via the written sources and by reconstructing some of the recipes.

Notes

1. Hawthorne, J. G. and C. S. Smith. 1979. *Theophilus on Divers Arts*. New York: Dover Publications, 41. See also Scholtka, A. 1992. *Theophilus Presbyter: Die maltechnischen Anweisungen und ihre Gegenüberstellung mit naturwissenschaftlichen Untersuchungsbefunden*. *Zeitschrift für Kunsttechnologie und Konservierung* 6 (1):1–54.
2. Cennini, C. 1960. *The Craftsman's Handbook*. Translated by D. V. Thompson. New York: Dover Publications, 33.
3. Borradaile, V. and R. Borradaile. n.d. *The Strasburg manuscript: a medieval painters' handbook*. München: Callwey, 55–7. Passage translated by the author.
4. Ludwig, H. 1882. *Lionardo da Vinci. Das such von der Malerei. Nach den Codes Vaticanus (Urbinas) 1270*. Wien: Braumüller (Quellenschriften für Kunstgeschichte und Kunsttechnik des Mittelalters und der Renaissance), 15:244. Passage translated by the author.
5. Merrifield, M. P. 1967. *Original Treatises on the Arts of Painting*, Vol. 2. New York: Dover Publications (2):822.
6. van de Graaf, J. A. 1958. *Het De Mayerne Manuscript als bron voor de schildertechniek van de barok*. *British Museum, Sloane 2052*. Proefschrift . . . Mijdrecht: Drukkerij Verweij, 142. Passage translated by the author.
7. Pernety, A. J. 1972. *Dictionnaire portatif de peinture, sculpture et gravure*. Geneva: Minkoff Reprint, 547. Passage translated by the author.
8. Kuhn, H. 1993. Verdigris and copper resinate. In *Artists' Pigments*. Ed. A. Roy. Washington: National Gallery of Art, 136. For preparation and identification of green copper pigments, see Ellwanger-Eckel, F. 1979. *Herstellung und Verwendung kunstlicher grüner und blauer Kupferpigmente in der Malerei*. Stuttgart: Institut für Museumskunde an der Staatlichen Akademie der Bildenden Kunst.
9. Hawthorne and Smith, op. cit., 33.

10. Thompson, op. cit., 61.
11. Berger, E. 1975. *Quellen und Technik der Fresco-, Oel- und Tempera-Malerei des Mittelalters* . . . Walluf-Nendeln: Sandig Reprint, 195.
12. Borradaile, op. cit., 55-7.
13. Armenini, G. B. 1977. *On the true precepts of the art of painting*. Edited and translated by E. J. Olszewski. Burt Franklin, 194.
14. van de Graaf, op. cit., 174. Passage translated by the author.
15. van de Graaf, op. cit., 164. Passage translated by the author.
16. Brinkmann, P. W. F., et al. 1984. Het Lam Godsretabel van van Eyck . . . *Bulletin de l'Institut Royal du Patrimoine Artistique* (20):164.
17. Massing, A. and N. Christie. 1988. *The Hunt in the Forest by Paolo Uccello*. Bulletin of the Hamilton Kerr Institute (1):36.
18. Veliz, Z. 1986. *Artists' Techniques in Golden Age of Spain*. Cambridge: Cambridge University Press, 168-69.
19. Crocker, J. M. 1982. *Der wohl anführende Mahler*. Rottenburg: Kremer-Reprint, 110.
20. Thompson, op. cit., 29-30.
21. Ludwig, op. cit., 244-7. Passage translated by the author. See also Chastel, A. n.d. *Leonardo da Vinci. Samtliche Gemalde und die Schriften zur Malerei*. [Darmstadt]: Wissenschaftliche Buchgesellschaft, 351-52.
22. van de Graaf, op. cit., 174.
23. Goetghebeur, N., and L. Kockaert. 1980. Le grand Calvaire d'Albert Bouts au Musée des Beaux-Arts de Bruxelles. *Bulletin de l'Institut Royal du Patrimoine Artistique* (18):5-20.

Abstract

The discovery of three “new” pigments is described. Their history is traced through the literature of pigments, ceramics, and glass. Tin white, previously undiscovered, is followed from Iraqi ceramics to its occurrence as a pigment on Jain miniatures in India. Burnt green earth, mentioned by early Italian and nineteenth-century English writers, is identified on nineteenth-century oil paintings. Cobalt oxide colorant is followed from Persia to Europe and China and finally, in a new form, to Venetian enamels and as smalt on Hindu miniatures.

Connections and Coincidences: Three Pigments

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Introduction

There are certain advantages in being a generalist rather than a specialist. In this paper, the author hopes to show some of the connections and coincidences that occur when a wide range of materials and objects are analyzed in the same laboratory.

Tin white

The pigment known as tin white is elusive. It is mentioned occasionally in medieval and later European literature, but has never been identified on paintings.

Tin oxide was used first as an opacifier in ceramic glazes to reproduce Chinese porcelains in ninth-century Iraq. From there it spread throughout the Near East (by the tenth century) and to Spain (by the thirteenth century) via North Africa (1). By the twelfth century it was being used to opacify glass. It has been identified in twelfth-century Byzantine colored mosaic tesserae in Tchernigov, Ukraine (2). In 1612, in the first book devoted to glassmaking, Neri describes the preparation of enamel by adding calcined tin to calcined lead (3). The earliest dated European tin white glass is late fifteenth-century Venetian (4). White glass and enamel of the succeeding centuries is almost always opacified with tin (5).

Writing in the late thirteenth century, Eraclius gives two very similar recipes for white glaze used for earthenware (6). White glass was ground very finely, mixed with sulfur, painted onto the ceramic and fired. Tin is not mentioned but must have been the opacifier. The purpose of the sulfur is not known. It would not have survived the firing.

The Paduan manuscript written in Venice in the seventeenth century (but copying sixteenth-century material), has another similar recipe, but here it is for a pigment: “Un bianco bellissimo—Si piglia cristallo di Venetia . . .” [take some powdered Venice glass, add to it a third part of powdered sulfur] (7). The mixture was heated to red heat in a pipkin, cooled, and ground. Merrifield suggests that it was used for painting miniatures (8).

Harley quotes an English source (ca. 1500): “For to make Ceruse. Take plates of tinne and beate them as thinne as thowe maist . . .” (9). The tin was hung in a sealed barrel with vinegar for several weeks. The method is exactly the same as that used to produce lead or flake white. Indeed, the name ceruse was applied in England to both tin and lead white, and perhaps more correctly to a mixture of lead white and chalk.

Harley says that documentary sources indicate that tin white was used in manuscripts. Her suggestion that it became obsolete because manuscript illumination declined cannot be substantiated, as the pigment has not been identified in any English or European miniatures. In the seventeenth century, Van Dyck tried it in oil and reported that it had insufficient body and was only useful for manuscript illumination (10). Mytens found that it blackened in sunlight, spoiled white lead if the two were mixed, was useless in oil, and also in distemper if exposed to air (11). In the late eighteenth century, France Guyton de Morveau experimented with pigments and reported that tin white was unsuitable as it tended to yellow or blue (12).

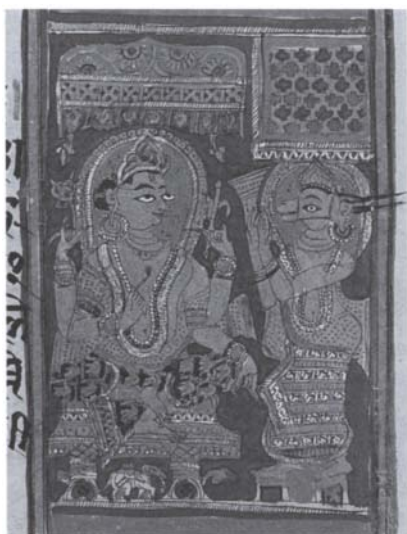


Figure 1. Tin white pigment, details on a sixteenth-century Jain miniature. Photograph by Paul Robins (Photo Studio), courtesy of the Victoria & Albert Museum (I.S.84–1963 f. 15).



Figure 2. Tin white pigment, details on a sixteenth-century Jain miniature. Photograph by Paul Robins (Photo Studio), courtesy of the Victoria & Albert Museum (I.S.46–1959 f. 26).

Tingry, in 1830, gives a recipe for “Another Cremnitz White,” which he describes as a beautiful pearly white, too expensive for house painting, but “it would, no doubt, be attended with great advantage in painting pictures” (13). This white was a mixture of tin white, one-fourth part zinc white and one-eighth part white clay separated from Briancon white.

Linton describes tin white (oxide of tin) as, “too feeble in body . . . to be of any service to the oil painter . . .” (14). He does, however, add that it may be unaffected by “injurious gases.” Field also thinks the pigment to be poor, writing that it “dries badly and has almost no body in oil or in water, it is the basis of the best white in enamel painting” (15). In 1951, Mayer merely states that it is not a paint pigment at all (16).

Tin white, therefore, has two main uses: as an opacifier in glass, enamel, and ceramic glazes from the ninth to twentieth centuries; and as a possible pigment in manuscripts and miniatures from the fifteenth to seventeenth centuries. Even in the short review given here, three quite different recipes for its preparation are given from the following eras: (1) circa 1500, England, tin oxide; (2) circa 1580, Italy, white glass powder opacified with tin oxide; and (3) circa 1800, England, a mixture of tin oxide, zinc oxide, and white clay.

During a research program in the laboratory of the Victoria & Albert Museum, methods for nondestructive identification of the pigments on Indian miniatures were studied (17). Incident light microscopy, energy-dispersive X-ray fluorescence (EDXRF) spectroscopy, and ultraviolet and infrared color reversal photography were used.

Several Jain miniatures were examined; these small, jewel-like, utterly distinctive paintings from Western India were of the fifteenth and sixteenth centuries. The areas of white paint were frequently restricted to details of textiles and jewelry (Figs. 1, 2). Two of the miniatures had tin present as the major constituent in areas of white pigment. Because red lake and, in one case, gold leaf were beneath the white, this was regarded as interesting but not conclusive of tin white being present.

Tin was then found on a third Jain miniature, possibly dating from the fifteenth century, with carbon black and verdigris in the same area. Three more paintings were chosen from the same manuscript as one of those examined earlier, as it was possible to focus on areas with no other pigment or only gold leaf. In all three, tin was the major constituent (Fig. 3). It is possible,

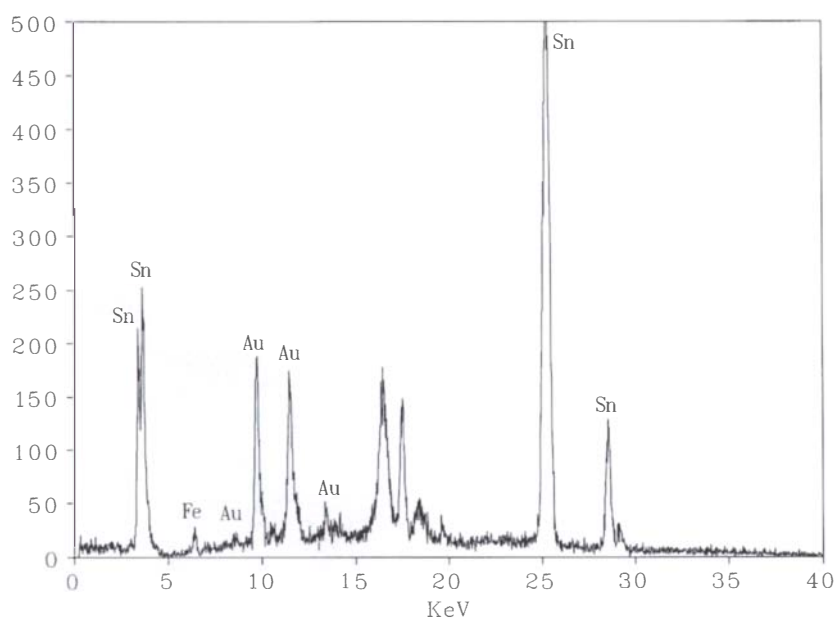


Figure 3. EDXRF spectrum of tin white pigment on a sixteenth-century Jain miniature. Spectrum prepared by David Ford, Science Group, Victoria & Albert Museum (I.S.46–1959 f. 49).

therefore, to say that the pigment is a tin white (Table 1). A mixed tin-lead white was identified on a seventeenth-century Hindu miniature; much overpainting with zinc white confused the picture.

It has not been possible to determine the constitution of the Indian tin white; the size and delicacy of the miniatures prohibits the removal of a sample. The pigment is a clean, brilliant white and appears reasonably opaque. It is probably tin oxide.

Although the date of these miniatures falls into the same period in which the pigment is said to have been used in Europe, it seems unlikely that the Jain school was using the Western pigment. It is probable, however, that it developed from the use of tin oxide in ceramics, ultimately deriving, as it did in Europe, from the Near East or neighboring Persia.

Burnt green earth

Green earth in its various forms has been used as a pigment through much of Eurasia for 2,000 years. Vitruvius wrote of it in the first century B.C.E. Burnt green earth seems to be mentioned first in the sixteenth or seventeenth centuries. The Paduan manuscript lists it as a color for miniature painting and also records that “the shadows of the flesh are made with *terra 'ombra*, *terra verde* burnt, and asphaltum” (18). The Volpato manuscript gives the method of preparation (19). Merrifield quotes Lomazzo, who directs that shadows on flesh should be made with burnt terra verde and *nero di campana* or umber (20). She says that “modern writers do not mention this colour, but the use of it has been revived by an eminent English artist, under the name of ‘Verona Brown’ ”(21).

Linton mentions it briefly with terre verte: “When calcined, it forms another beautiful pigment called Verona Brown” (22).

Toch says Verona brown is a “fancy name” for a mixture of burnt umber and burnt or raw sienna (23). At the time of the Constable and Turner research projects in England, the author examined two paint boxes of the relevant period in the Victoria & Albert Museum collections. One was said to have

Table 1. White pigments on fifteenth- to eighteenth-century Jain miniatures.

Accession No.	Date	Pigments
IS 2-1972	c.1460	Kaolin, mica
Isacco 1	15C	Calcium white
Isacco 2	15C	Tin white
IS 46-1959 f26	16C	Tin white
IS 46-1959 f45	16C	Tin white
IS 46-1959 f47	16C	Tin white
IS 46-1959 f49	16C	Tin white
IS 84-1963 f15	16C	Tin white
IS 82-1963	16C Hindu	Calcium white, mica
Private owner	17C Hindu	Tin - lead white
IS 2-1984	18C	Lead white

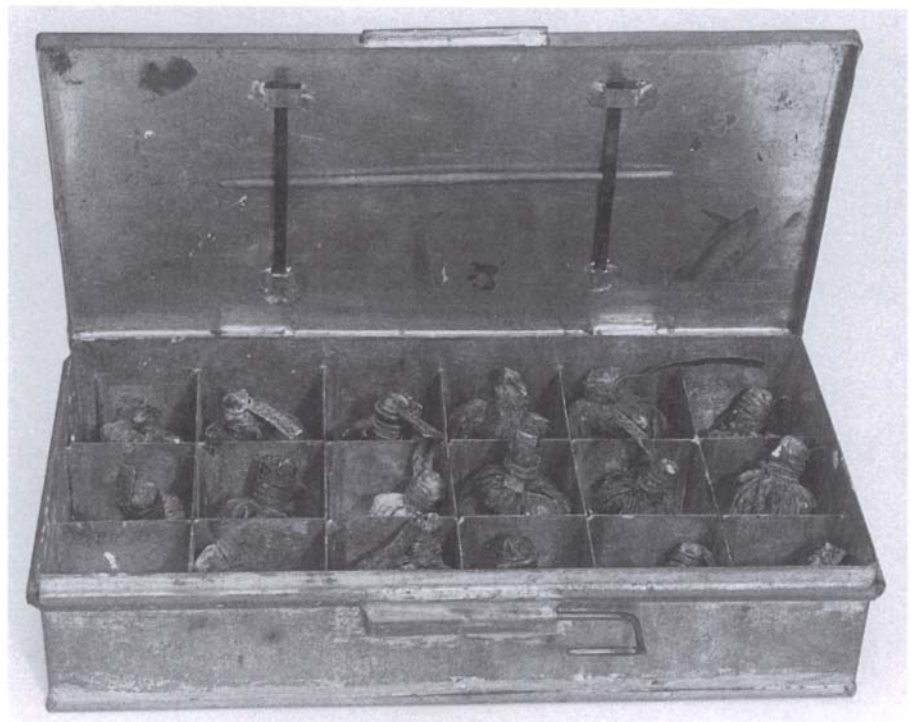


Figure 4. Paint box, said to have belonged to William Turner, with bladders of oil paint, including Gebr. Terra di Verte and Gebr. Grüne Erde. W.65-1920. Courtesy of the Victoria & Albert Museum.

belonged to William Mallord Turner (Fig. 4). It contained seventeen bladders of solidified oil paint, all of which had been opened and sealed with a tack. Each was labeled in German or English. Two were named as *Gebr. Terra di Verte* and *Gebr. Grüne Erde*, the term “Gebr.” coming from the German *gebrannte* for burnt or roasted (24).

EDXRF analysis of the paint on the surface of the bladders showed iron to be the major constituent with traces of manganese and titanium. The *Terra di Verte* contained a trace of calcium, the *Grüne Erde* considerably more with traces of potassium, rubidium, and strontium (frequently present in calcium deposits). Green earth is a complex silicate colored by iron with a structure similar to mica (25).

Dispersions of the two paints were made. The *Gebr. Terra di Verte* was a rich orange-brown comparable to burnt sienna but more translucent. The *Gebr. Grüne Erde* was similar to raw sienna, but of a greener tone. This must have been burned at a lower temperature, as a few green particles remained. Under the microscope, the pigments were identical to green earth, with the overlapping plates of the crystals visible on the larger particles. Calcite was seen in both, but the *Gebr. Grüne Erde* had, as indicated by EDXRF, a higher proportion of it. The labels suggest that both bladders were prepared in Germany, perhaps from two different sources of green earth.

The appearance of the samples brought to mind the unidentified brown pigment seen by the author in several nineteenth-century landscape paintings, usually mixed with Prussian blue, ochres, and so forth, to produce greens and browns. It was suggested that it was the brown seen in the cross sections from a painting by Constable then being examined. SEM-EDX analysis of the latter at the National Gallery laboratory produced a spectrum identical to that for green earth. It was later identified in several Constable paintings dating from 1811 to 1829 mixed in greens and browns (26, 27). Could Merrifield’s “eminent English artist” be John Constable?

The author has tentatively identified burnt green earth in paintings by Peter de Wint and J. F. Millet (28).

Green earth was rarely used in England. The author has seen it only in seventeenth- and eighteenth-century wall paintings (oil) and cartoons by Verrio, Laguerre, Thornhill, and Robert Adam, all of whom trained in Italy or France. Verona brown seems to have been adopted in the early nineteenth century as a translucent addition to the earth and organic browns then available. Verona was a source of one of the better green earths, but was abandoned earlier this century (29).

By coincidence, Constable Project researcher Sarah Cove visited Brussels and brought the author a bottle of pigment, *Grüne Erde Gebr.*, from an artists’ suppliers. This modern sample is a darker, duller brown; perhaps burned at a higher temperature than the earlier examples, it too contains calcite.

Brown pigments tend to be neglected, partly, no doubt, because of the difficulty in distinguishing the multitude of ochres, organic earths, and lakes. Burnt terra verte has a quite distinctive appearance, is easily identifiable by EDX, and may be more common than previously thought.

Smalt

The earliest blue glass colored with cobalt is from Eridu, Mesopotamia, circa 2000 B.C.E. Recipes survive from Ashurbanipal’s library in Nineveh, circa 650 B.C.E. The Indians adopted Sumerian technology and were making cobalt blue glass by the sixth century B.C.E. (30). The Egyptians were using cobalt by circa 1400 B.C.E. The Romans were familiar with it; it was common in Western Europe in the seventh century and occurs in the Sassanian and Islamic periods (31).

The first appearance of smalt is in a wall painting (ca. 1000–1200 C.E.) in Khara Khoto, Central Asia, and in the Church of Our Saviour of the Mon-

Table 2. Unusual occurrences and constituents of smalt and blue enamel.

Source	Accession Number	Blue pigment or enamel	Date	EDXRF Analysis	
				Minor	Trace
Basohli miniature	I.S.50-1953	smalt	1660-70	Pb*	KCa Fe Co Ni Cu As
* *	I.S.51-1953	smalt	1660-70	As Pb*	KCa Mn Fe Co Ni Cu Zn Bi
* *	I.M.87-1930	smalt	1730-35	As	KCa Fe Co Ni Zn Pb Bi
* *	I.M.88-1930	smalt	1730-35	As	KCa Fe Co Ni Zn Pb Bi
Bundi miniature	D.379-1889	smalt	c.1770	Pb*	KCa Ti Fe Co Ni Cu As
Venetian jug	273-1874	enamel	1472-1525	As	KCa Mn Fe Co Ni Cu Zn Pb Bi Sr Sn
* <i>tazza</i>	5496-1859	enamel	late 15th C.	As	KCa Mn Fe Co Ni (Au) Pb Bi Sr
* bowl	C.170-1936	enamel	1521-23	As	KCa Ti Mn Fe Co Ni Cu Pb Bi Sr
* bowl	C.160-1936	enamel	early 16th C.	As	KCa Mn Fe Co Ni Cu Zn Pb As Bi Sr (Sn Sb)†
* bowl	5489-1859	enamel	1500-1600	As	KCa Mn Fe Co Ni Cu (Au) Pb Bi Sr Sn Sb
S. German oil painting	C.I.A. No 302‡	smalt	15th - 16th C.	-	Si K Fe Co Ni Pb* Bi

* lead from lead white pigment

† tin and antimony from yellow enamel applied over blue

‡ Courtauld Institute of Art, SEM-EDX analysis

astery of Chora (Kariye Camii), Constantinople (1325–1453 C.E.) (32, 33). It is likely that the smalt derived from Middle Eastern and Near Eastern blue glass.

The earliest known source of cobalt ore is Khashan, Persia; the Mesopotamians and Egyptians probably obtained it from there. This suggests that the ore's coloring properties were already known to the Persians. Medieval European glass was tinted with Damascus pigment or zaffre, the Arabic name for cobalt oxide, again suggesting a Near Eastern source (34).

Cobalt oxide, known as *sulimani*, was imported into China from Persia in the Tang period; by the fourteenth century it was transported by sea from the Persian Gulf via Sumatra. Muslim merchants residing in China influenced ceramic designs; much of the blue and white ware was produced for the Islamic market (35).

Cobalt blue glass and glaze was known from China to Western Europe and yet throughout this period (3000 B.C.E. to ca. 700 C.E.) the most important blue pigment was Egyptian blue, a frit colored with copper, at its best rivaling azurite but often appearing in paler turquoise shades. The terminal date is circa 850 C.E. on a fresco in the church of San Clemente in Rome (36). It seems unlikely that the secret of making Egyptian blue was lost to the Romans during the turmoil of the Teutonic invasions, as glass and enamel colored with copper continued to be made both in Italy and many other countries.

In Europe there is an inexplicable hiatus in the use of blue pigments deriving from glass from about 850 to 1490 C.E. The Venetians were making cobalt glass by the mid-fifteenth century; the earliest references to smalt are by Leonardo da Vinci and Perugino in the 1490s (37). It has been identified on an altarpiece (1493) by Michael Pacher (38). Cobalt was discovered in Saxony in the mid-fifteenth century and fully exploited by around 1520. This may explain the greater utilization of smalt in the sixteenth century (39, 40).

Cobalt ores combine iron with nickel and/or arsenic, the latter volatilized in the smelting process. Cobalt was also obtained from the residue in the separation of bismuth (41). The metal oxides were fused with sand and potash to produce zaffre (the Arabic name still being used) and sold to glassmakers.

During research on Indian miniatures, the author found smalt on one Bundi example (ca. 1770 C.E., central India, Hindu). The pigment, not previously identified on Indian paintings, contained cobalt, iron, nickel, and a little arsenic (Table 2) (Plate 13).

In a later project examining miniatures from the northern Hindu states, smalt was found on four miniatures from Basohli, a tiny state in the Himalayan foothills north of Lahore (42, 43). In one example (1660–1670 C.E.), smalt was used to paint areas of the sky and Krishna's skin; the pigment contained

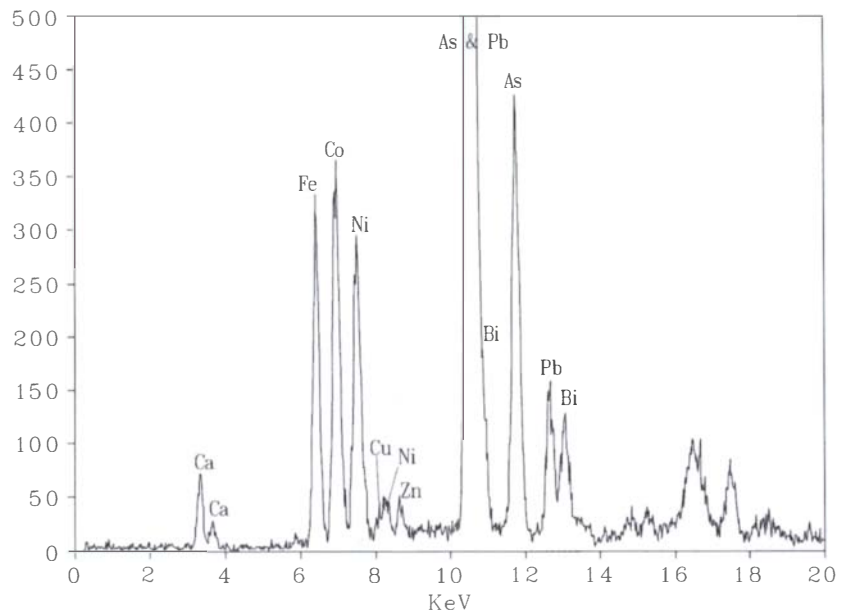


Figure 5. EDXRF spectrum of smalt with a high arsenic content and traces of bismuth and lead. Krishna and Girls, 1730–1735, Basohli. Spectrum prepared by David Ford, Science Group, Victoria & Albert Museum (I.M.87–1930).

cobalt, iron, nickel, and a trace of arsenic. On another of the same date and on two later miniatures (1730–1735 C.E.), a very different type of smalt was found in the sky and Krishna’s skin (Plate 14). EDXRF spectra showed a high arsenic content with iron, cobalt, nickel, bismuth, and lead (Fig. 5). No orpiment (arsenic) was present on these paintings.

By coincidence, the author had been analyzing a number of enameled Venetian glass vessels (44). Blue enamel, opacified with tin oxide, occurs on many of these objects. In a group of five, all late-fifteenth to early-sixteenth century, the blue enamel appeared to be opacified with arsenic; bismuth and lead were also present (Fig. 6). Lead oxyarsenate, $3\text{Pb}_3(\text{AsO}_4)_2 \cdot \text{PbO}$, is said to have first been used as an opacifier in European heavy lead glass in the eighteenth century (45). Neither the Venetian enamel nor the Basohli smalt seem

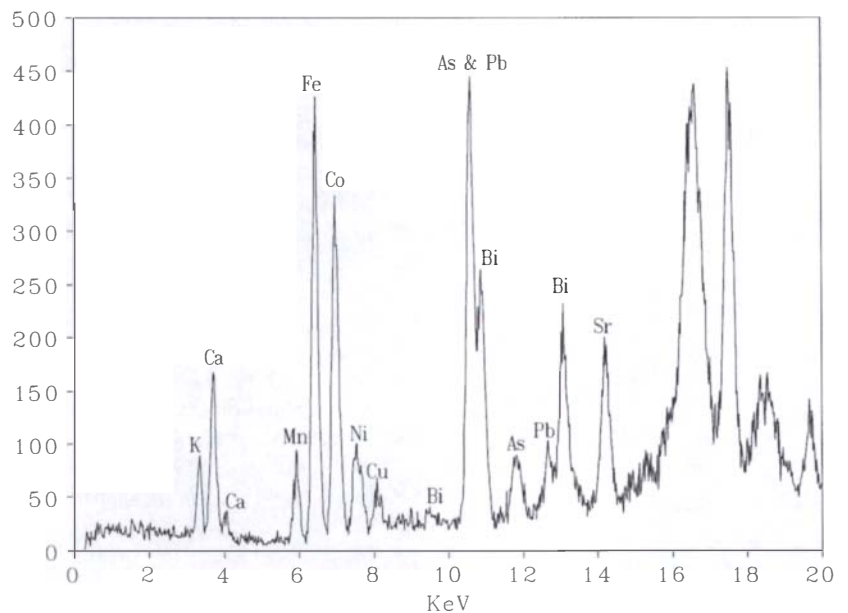


Figure 6. EDXRF spectrum of cobalt blue enamel with a high arsenic content and traces of bismuth and lead. Venetian enamelled glass bowl, 1521–1523. Spectrum prepared by David Ford, Science Group, Victoria & Albert Museum (C.170–1936).

to contain sufficient lead to fulfill the requirements of the above formula or for a heavy lead glass.

In Venice, there is blue enamel opacified with arsenic 250 years before it is known to have been used to opacify glass. In Basohli two centuries later, a pigment previously unknown in India was used and in three cases; it is very similar to the Venetian enamel. The enamels are of exactly the same period as when smalt first appears in European paintings, but in no example yet identified does it contain arsenic and bismuth. Do we have two completely independent discoveries, or were both importing enamel frit from some Middle Eastern source that was using arsenic as an opacifier earlier than the Venetians? The author has been unable to find any analyses which may hold the answer to the sources of Persian or Middle Eastern enamels of the relevant period.

As a footnote, smalt containing a trace of bismuth was found on a south German oil painting (ca. 1400–1500 C.E.) in the collection of the Courtauld Institute of Art (46). In this case, it seems likely that the cobalt oxide colorant was obtained from the residue of the smelting of bismuth (as described previously), and that it is an accidental constituent.

Conclusion

Trade, industry, and art are ancient, ubiquitous, and international. This paper has endeavored to show that “new” pigments can still be found in unexpected places. The connections and coincidences that become apparent to the scientist through laboratory testing indicate historical trade and industrial developments, and may sometimes ultimately depend on the craftsman who experiments with new materials. Our ability to understand these connections and coincidences requires knowledge of metalworking, ceramics, glass, and enamels to explain these connections and coincidences both in time and place.

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20. Merrifield, op. cit., ccxxi–ccxxiii.
21. Merrifield, op. cit.
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Abstract

A comprehensive examination was conducted on a set of twenty-three seventeenth-century Tibetan *thangkas* owned by the Museum of Fine Arts, Boston (BMFA). The examination was undertaken because of the dearth of technical information on Tibetan *thangkas* in Western literature. Infrared reflectography was used to document color notations drawn on the ground layer by the artist(s) as a guide for the artist(s) and apprentices. Samples were taken from areas displaying such notations and multiple analytical techniques were utilized to identify the pigments. The existence of more than one color-code system became evident when the color notations and the identified pigments from the BMFA set were compared to those found on other Tibetan paintings. Nine comparative paintings were examined, four from the BMFA and five from the Los Angeles County Museum of Art.



Figure 1. Detail IR-reflectogram from The Buddha Shakyamuni Preaching at Dhan-yakataka, showing color codes throughout an offering bowl of jewels. Denman Waldo Ross Collection, Museum of Fine Arts, Boston (06.333).

An Investigation of Palette and Color Notations Used to Create a Set of Tibetan Thangkas

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Introduction

Tibetan *thangkas* are scroll paintings that incorporate Buddhist iconography. The painting is done on cloth that is stitched into a framework of silk borders. Along the top edge is a wooden stave from which the painting is hung. Along the bottom edge is a wooden dowel around which the *thangka* is easily rolled for storage and transport. In 1906 the Museum of Fine Arts, Boston acquired a set of twenty-three *thangkas* (1). The paintings in this set had lost their original *thangka* format and were mounted on panels upon their arrival. Originally thirty-three or thirty-four paintings comprised the set, depicting the thirty-two Kings of Shambhala, the Buddha Shakyamuni, and possibly a Kalachakra Mandala. The existing set, referred to as the "Shambhala paintings" throughout this paper, contains only the Shakyamuni and twenty-two images of the Kings (Plates 15, 16). Over the years the set has been assigned various dates and places of origin. Today it is generally accepted to originate from late seventeenth-century Tibet.

Initially, each Shambhala painting was surveyed by infrared reflectography (IRR), a nondestructive technique that enabled color codes on the ground layer to be viewed (2). The color notations are handwritten in Tibetan *dbu.med* script. In areas with complex juxtapositioning of numerous colors (such as offering bowls containing multicolored jewels, or garments with intricate folds), notations were observed in abundance (Fig. 1). Once the infrared data were compiled, X-ray fluorescence (XRF) analyses of twelve to fifteen areas were carried out. After examining these results, approximately ten areas were sampled. Multiple analytical techniques were utilized, including polarized light microscopy (PLM), Fourier transform infrared spectroscopy (FTIR), electronprobe microanalysis (EPMA), X-ray diffraction (XRD), high-performance liquid chromatography (HPLC), ultraviolet/visible absorption spectrometry (UV/vis), and fluorescence spectrophotometry (FS). Black pigments, presumably carbon-based, were not studied. Decorative gold was also not examined except for initial XRF analyses.

Preparing the support

The Shambhala *thangkas* are all painted on cotton cloth supports. According to Jackson and Jackson, who documented the practices of living *thangka* painters, the painting support is typically first made taut by stitching it to four pliable sticks (3). It is then laced into a larger wooden frame, leaving a space of several inches between outer and inner frames. This space is crucial for adjusting tension. The support is stiffened by sizing both sides with a gelatin solution. A mixture of finely ground white pigment and size solution is then

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Table 1. Tibetan color names, translations, and identified pigments.

COLOR	NOTATION	ENGLISH SPELLING	TIBETAN COLOR NAME	ENGLISH TRANSLATION	PIGMENTS IDENTIFIED
white	ཀ	ka	dkar po	white	kaolin (2,4,6)
blue	ཐ	tha	mthing	azurite	azurite (1,2,4,6)
light blue	ཇ	nag	ang	light blue	azurite, kaolin (2,3,4,6)
lighter blue	ཇ ལ	nag kya	ang skya	light blue + white	azurite, kaolin (2,3,4,6)
green	ཇ	pa	spang po	malachite	malachite, brochantite (2,4)
blue/green	ཇ ལ	jang	sbyar liang	"compounded green"	orpiment/realgar, indigo, kaolin (1,2,3,4,6)
blue/green	ཇ ལ ལ	'jang	sbyar liang	"compounded green"	orpiment/realgar, indigo, kaolin (1,2,3,4,6)
light blue/green	ཇ ལ ལ	jang kya	liang skya	"compounded green" + white	sample not taken
dark blue/green	ཇ ལ ལ ལ	jang nag	liang nag	"compounded green" + black	sample not taken
yellow	ཇ	se	ser po	yellow	orpiment, kaolin, red lead (1,2,4,6)
yellow	ཇ ལ	ser	ser po	yellow	sample not taken
yellow	ཇ ལ	sare	ser po	yellow	orpiment, kaolin, red lead (1,2,3,6)
bright red	ཇ	ga	rgya mtshal	Chinese or Indian vermilion	vermilion, kaolin (1,2,4,6)
dark red	ཇ ལ	ma	dmar po	red	analyses pending
pink	ཇ ལ	na	na ros	lac dye + white	lac dye, kaolin (1,2,5,6)
pink	ཇ ལ ལ	na kar	na ros + dkar po	lac dye + white	analyses pending
orange	ཇ ལ	ja	li khri	minium	red lead, calcite (1,2,3,4,6)

1 = polarized light microscopy (PLM)
 2 = Fourier transform infrared spectroscopy (FTIR)
 3 = electronprobe microanalysis (EPMA)

4 = x-ray diffraction (XRD)
 5 = fluorescence spectrophotometry
 6 = x-ray fluorescence (XRF)

applied; one coat on each side usually suffices. This ground is then burnished with a stone or conch shell until ground and cloth become a flexible entity, as is necessary for a rolled painting. Next, the underdrawing is rendered upon the ground layer, a process that can take several steps and different methods of application. Once the underdrawing is finalized, the painter often indicates colors with notations before painting begins.

All twenty-three Shambhala paintings have grounds in which magnesite ($MgCO_3$) is the only constituent. FTIR and, in some cases, XRD established this fact. Three of the several major deposits of magnesium carbonate worldwide are located in the Sheng-king province of Manchuria, Liao-Tung peninsula, and Taikwayodo, Korea (4).

The FTIR spectra of the ground and pigment samples do not indicate any type of binding medium, which is not surprising given their lean nature (low binder to pigment ratios). Analysis of several samples by HPLC indicated the presence of animal glue. Due to the small size of the samples, the ground layer could not be separated from the upper pigment layer. It is assumed that both layers contain a glue binder. Yak glue, made from the remains of the most common beast of burden on the Tibetan plateau, is generally considered the most probable binder (5).

Color names

For easier referral, transliterations of Tibetan color names are given in parentheses following color codes. For the actual color codes written in Tibetan *dbu.med* script, refer to Table 1. The approximate height of the color codes is 2–3 mm.

White. The color code for white is *ka* (*dkar po*) (6). This notation is found on all twenty-three Shambhala paintings. *Ka* is used for clouds, offering tusks, garments, jewels, and conch shells. FTIR analyses of four samples and an XRD analysis of one sample indicated a clay mineral of the kaolin family. The analyses suggest that the clay is a hydrated alumino-silicate closest in characteristics to metahalloysite. This same type of clay, identified as kaolin throughout this paper, is also found as a component in several colored mixtures.

Blues. IRR uncovered the *dbu.med* character *tha* (*mthing*), meaning azurite (7). *Tha* is observed on twenty Shambhala paintings and is used for the sky, rock crags, jewels, and garments. Coarsely ground azurite was identified by PLM, XRD, and FTIR on five of the paintings. Jackson and Jackson state that the main deposit for azurite in Tibet was Snye-mo-thang in Gtsang (8).



Figure 2. Detail IR-reflectogram from The Twenty-ninth King of Shambhala, showing the color code ngo kya on the leg of a goat. Denman Waldo Ross Collection, Museum of Fine Arts, Boston (06.335).

The notation *ngo* (*sngo*), found on twenty-two Shambhala paintings, means light blue or sky blue (9). *Ngo* was used for sashes, linings of garments, jewels, nimbuses, rock crags, and lotus petals. Samples of this color taken from four paintings were identified as a mixture of azurite and kaolin. Further whitening of this pigment is indicated by the notation *ngo kya* (*sngo skya*) and is used to depict the color for water, a goat, the sky, and the skin color of a king (10, 11, 12). This notation is shown in Figure 2. The additional character *kya* indicates that more than 50 percent of the color mixture is white. An actual quantitative measurement is difficult to carry out; however, one XRD pattern of a *ngo kya* sample indicated a higher kaolin:azurite ratio than an XRD pattern taken from a *ngo* sample.

Greens. Basic green is denoted by *pa* (*spang*), an abbreviation for the Tibetan word meaning malachite (13). *Pa*, observed on all twenty-three Shambhala paintings, is used for rock crags, land masses, garments, jewels, and foliage. The green pigment was identified by FTIR and XRD in four samples as a mixture of malachite and brochantite. Since brochantite is associated with malachite deposits, the combination is probably a natural one (14). The mined source for malachite in Tibet was probably the same as previously mentioned for azurite (15).

A mixed green was found on twenty-one Shambhala paintings. Jackson and Jackson describe a “compounded green” (*sbyar ljang*) derived from a mixture of orpiment and indigo (16). The notation uncovered is *jang*, occasionally written *'jang*, and is used for nimbuses, mountains, lotus centers, and leaves. The color varies from deep blue to aqua to yellowish green. Five samples taken from five paintings were examined by FTIR, XRD, EPMA, and PLM. Examination of two of the five dispersed pigment slides revealed a mixture of realgar and clay. Two other slides contained a mixture of realgar, orpiment, and clay. The fifth contained a mixture of only orpiment and clay. Indigo, tentatively identified in three dispersed pigment slides, was positively identified by FTIR in one of the samples. UV/vis spectrophotometry analysis of these samples is planned for the future in hopes of definitively identifying indigo. The chromatic differences found in the samples may be due to the fugitive nature of the indigo or to the discoloration of either realgar or orpiment. Indigo may fade when applied thinly, especially when exposed to sunlight (17). Although each sample appears to be slightly different, it is thought that the original ingredients were the same: namely, clay, orpiment/realgar, and indigo. The notation *jang kya* (*ljang skya*), meaning light green, was revealed on two Shambhala paintings for decorative elements of a king’s throne, clouds, and land masses (18). The color notation *jang nag* (*ljang nag*), meaning dark green, is documented on four Shambhala paintings and is used for leaves and land masses (19). The paint covering this notation as well as the *jang kya* has yet to be sampled.

Yellow. Color notations for yellow (*ser po*) were documented on nineteen Shambhala paintings. The notations are actually written as one of the following three: *se*, *ser*, or *sare*. *Se* is the most abbreviated and *sare* is a misspelling, perhaps to facilitate writing. The pigment mixture for these notations was consistently found to contain orpiment mixed with kaolin and a small amount of red lead. Five samples from four paintings were taken from areas with *sare*. FTIR analyses indicate a kaolin-type clay, similar to the spectrum described for *ka*. Examination of four samples by EPMA identified silicon, aluminum, magnesium, and lead, as well as minor amounts of calcium, iron, and arsenic. PLM revealed clay particles mixed with spherical aggregates of red lead and fine to medium particles of orpiment. On one slide several large particles of realgar were identified. Realgar (arsenic disulfide) is often found in natural deposits with orpiment (arsenic trisulfide). Large deposits of orpiment exist near Chamdo in eastern Tibet and in the Yunnan Province of China (20, 21).

One of the samples taken from the area marked *se* was nearly colorless. Surface elemental analysis by XRF identified arsenic as a major element, yet neither

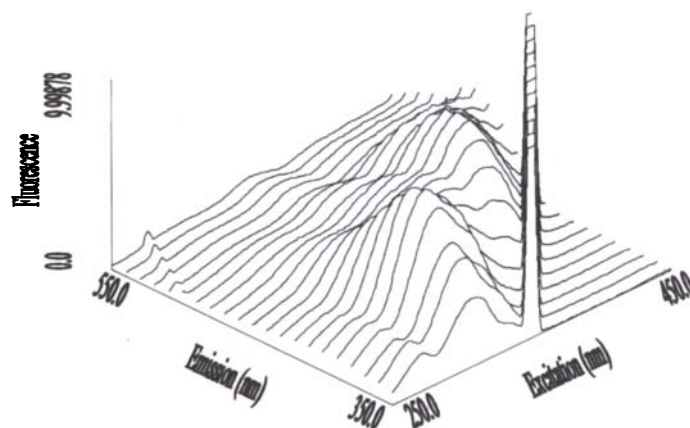


Figure 3. Three-dimensional spectrum of a sample from The Twentieth King of Shambhala. Denman Waldo Ross Collection, Museum of Fine Arts, Boston (06.334).

orpiment nor realgar was found by PLM. The FTIR spectrum showed kaolin. The remainder of the sample was analyzed by XRD. The majority of the peaks correlate with those of metahalloysite. The remaining peaks were assigned to kaolinite and arsenolite (As_2O_3), a white mineral. It is unlikely that arsenolite is original to the painting. The yellow orpiment probably faded and became a whitish arsenic trioxide. The impermanence of arsenic trisulfide has been documented elsewhere (22).

Reds. Two shades of red are observed on the Shambhala paintings. One is a bright red, the other is muted. The bright red uses the notation *ga* (*rgya mtshal*) for Chinese or Indian vermilion (23). *Ga* is found on fourteen paintings and depicts a color used for garments, lotus petals, and nimbuses. PLM, XRD, and FTIR identified the color as a mixture of vermilion and kaolin. Under the microscope, the vermilion particles appear as finely ground spherical particles with a deep orange-red color. Several historical references are given by Jackson and Jackson which state that Tibetan painters had access to both synthetic mercuric sulfide and to the natural mineral cinnabar from China, India, and Tibet (24).

The darker red is denoted by *ma* (*dmar po*), meaning red color (25). *Ma* is found on fourteen paintings and describes a color used for garments and sashes. The paint consists of a dual layer with a dark red organic coating over a red pigment layer consisting of vermilion and kaolin. Further analyses are pending and no conclusive identification has been made.

Pink. The color pink is used mainly for clouds but also for jewels, buckles, *makaras*, and *garudas* (26). Pink is denoted by *na* or, occasionally, *na kar*, and represents lac dye (*na ros*) mixed with a white pigment (27, 28). *Na* is found on all twenty-three Shambhala paintings. Areas were sampled on six of the paintings and examination of dispersed pigment slides revealed a clay base mixed with a red dyestuff. FTIR analyses identified the clay as kaolin, as described earlier. Identification of the dyestuff was achieved through absorption spectrometry. The identification was further confirmed by fluorescence spectrophotometry, utilizing a method described elsewhere (29). The pink was identified as a lac dye. Figure 3 shows a three-dimensional plot of the result, which is characteristic of lac. Jackson and Jackson state that much of the dyestuff was traditionally gathered and prepared in Tibet (30). The dye is extracted from sticks encrusted with a resinous secretion produced by the lac insect, *Kerria lacca* Kerr.; the resin is still found today in the eastern Himalayas where the warmer climate is more conducive to its formation.

Orange. The color orange is represented by *la*, an abbreviation for the Tibetan word for minium (*li khri*) (31). The notation was uncovered on garments, nimbuses, finials, crowns, flames, belts, jewelry, roof tiles, wheels, and vases. *La* was found on fifteen Shambhala paintings. Three sampled areas were examined by XRD, EPMA, FTIR, and PLM. The results identified a mixture of

red lead and calcium carbonate. Historical references given by Jackson and Jackson state that Tibetan painters did not use the natural mineral minium (32). Instead, the synthetic lead tetroxide was imported from China, Nepal, and India. Calcium carbonate was available in Tibet, particularly in Rinpung, an area north of Lhasa and the seat of government in the sixteenth century (33). In certain parts of Tibet, the cost of calcium carbonate was prohibitive and less expensive white pigments were often used. It is unknown why calcium carbonate was used to lighten the red lead. Other pigments were mixed with kaolin. The choice may be due to the purity and color of the calcium based pigment.

Summary of palette and color notations for the Shambhala set

Pigment identification determined that the notations on the ground layer directly correlate to the pigments used, supporting the belief that these notations were a guide for the artist(s) and apprentices. Pigments used for the respective color notations are similar throughout, which is not surprising given that the Shambhala paintings belong to one set.

The artist's palette for the Shambhala paintings from the Museum of Fine Arts, Boston (BMFA) consists of pigments derived from minerals or synthetic mineral analogues with the exception of two organic dyes, indigo and lac (Table 1). The pigments identified in this investigation deviate little from the modern-day painter's palette, as documented by Jackson and Jackson. The pure blue and green colors were painted with coarsely ground, unadulterated mineral pigments. All other colors were mixed with a white pigment either to lighten the color or to achieve translucency. The orange color is unique in that it was created by mixing calcium carbonate with red lead. In all other cases kaolin clay was used, perhaps due to its availability and low cost.

All color notations are handwritten in Tibetan *dbu.med* script on the ground layer. Some derivative colors are indicated by additional *dbu.med* characters to the root notation. Figure 2 is an infrared reflectogram depicting such a color notation. In this case, *kya* is added to the root notation *ngo*. The entire notation, *ngo kya* (*sngo skya*), indicates a light blue color. The second character, *kya*, is used to indicate whitening of the existing color, *ngo*. Another notation found indicates the darkening of an existing color. The notation has the additional characters *na* and *ga*, pronounced *nag*. These additions represent the Tibetan word for black (*nag po*). In the case of *jang nag* (*ljang nag*), *nag* indicates darkening of the existing green color, *jang*.

Comparative paintings

Comparative paintings from the Museum of Fine Arts, Boston and the Los Angeles County Museum of Art (LACMA) were examined using infrared reflectography (34, 35). Only a few pigment samples, however, were taken.

The LACMA nineteenth-century commemoration thangka for the *bhimaratha* rite from Tashi Lhunpo monastery in central Tibet did not reveal any color codes.

Another LACMA painting, *A Mahasiddha and Taklungpa Lamas* (ca. late 1700s) from Taklung monastery in central Tibet, revealed color codes written in Tibetan *dbu.med* script. Many of the notations were similar to those documented on the BMFA Shambhala paintings. One distinct difference, however, is in the manner of differentiating derivative colors. For a light green color, for example, the notation used was *pkya* (*spang skya*). A subjoined *kya* is added to the root character *pa* to indicate the addition of white (Fig. 4). Three other paintings examined using IRR revealed color codes in *dbu.med* script. These were *Shakyamuni with Disciples* and *Dharmatala*, two paintings from a set of five at the BMFA accepted as sixteenth-century eastern Tibetan; and LACMA's *Portrait of the Fifth Karmapa*, accepted as originating in eighteenth-century Kham, a region of eastern Tibet.



Figure 4. Detail IR-reflectogram from *A Mahasiddha and Taklungpa Lamas*, showing the color code *pkya* on a landmass. Los Angeles County Museum of Art, Los Angeles (M.81.206.12).

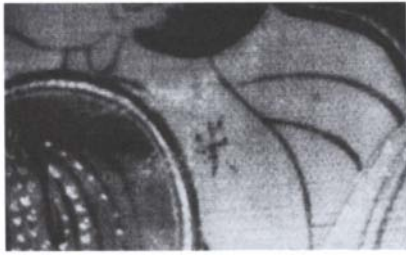


Figure 5. Detail IR-reflectogram from Shakyamuni and the Eighteen Arhats, showing a color code written in Chinese on an Arhat's back. Los Angeles County Museum of Art, Los Angeles (M.83.105.18).

Shakyamuni and the Eighteen Arhats, owned by LACMA and thought to be an eighteenth-century work from the Kham region, has color codes on the ground layer written in Chinese. Unlike the brilliant white magnesite ground found in the Shambhala paintings, this ground is buff-colored and composed of hydrocerussite and kaolinite. Two color-code systems are employed. The first is numerical: numbers represent specific colors. The second uses Chinese color names or idioms. Under the dark blue pigment of a begging bowl, IRR revealed the Chinese character for the number seven. The pigment was identified by PLM and FTIR as azurite. On an Arhat's back, IRR revealed the Chinese character for hulled rice (Fig. 5). Examination of a dispersed pigment slide revealed orpiment mixed with a small amount of red lead. A character not yet translated was uncovered on several deep red colored areas. Examination of a dispersed pigment slide revealed vermilion mixed with a small amount of red lead.

Another LACMA painting with Chinese color codes is *Palden Remati and Her Retinue*, accepted as originating from the Gelukpa monastery in Central Tibet, 1800–1850 C.E. This painting employs the two color-code systems described earlier with similar notations. The Chinese numbers for three and seven were used to denote a light blue color. This color has yet to be sampled. Presumably “seven” represents azurite and “three” represents the second addition of a white pigment.

Two BMFA paintings displaying Chinese color codes come from a set of five entitled *Stories from the Life of Buddha*. The set is thought to be eighteenth-century Tibetan. Again, evidence of the two color-code systems described earlier as well as notations for derivative colors were found on these paintings. The Chinese numbers for two and six are used to denote a light green. This color has yet to be sampled. Presumably “six” represents malachite and “two” the first addition of a white pigment.

Conclusion

Since thangka painting is a tradition passed on from master to apprentice, determining palette and deciphering color-code systems may prove to be helpful in the identification of specific workshops or painting lineages. The color-code system used on the BMFA Shambhala paintings has several distinctive traits. These include an additional character *kya* (*skya*) for whitish tints (Fig. 3) and the additional characters *na ga* (*nag*) for darker tints. The artist of the painting *A Mahasiddha and Taklungpa Lamas* indicated whitish tints with a *kya* subjoined to the root notation (Fig. 4). This system for distinguishing derivative colors is similar to one still practiced by some modern Tibetan thangka painters. The paintings with color codes in Chinese script pose many questions which are beyond the scope of this paper. In terms of the ethnic background of the creators of these works, one can only speculate. Perhaps the painters were Chinese, since a native Tibetan speaker would be unlikely to write such “private” communications in a foreign script. On the other hand, a bilingual Tibetan might use Chinese characters to communicate with Chinese apprentices or coworkers. Likewise, one can only speculate on whether such paintings were produced in Tibet or China. In order to answer these questions, more infrared data and pigment analyses need to be compiled from thangkas of known Tibetan as well as Chinese origin.

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tributions, the authors would like to acknowledge Richard Newman at the Museum of Fine Arts, Boston.

Notes

1. Ross, D. W. 1904. The purchase of twenty-six Tibetan paintings from Mme. Tangeveil, Paris. Unpublished typed letter to M. S. Prichard. Boston: Museum of Fine Arts.
2. An infrared TV camera equipped with a Hamamatsu No. 2606-06 vidicon was used at the BMFA.
3. Jackson, D., and J. Jackson. 1984. *Tibetan Thangka Painting: Methods & Materials*. London: Serindia Publications, 15-23.
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5. Shaffel, A. 1986. Notes on the technique of Tibetan thangkas. *Journal of the American Institute for Conservation* 25 (2):98.
6. Jackson, op. cit., 174.
7. Ibid., 175.
8. Ibid., 75.
9. Kocharov, A., and Chating Jamyang Lama. 1993. Personal communication. Dharamsala, India: Library of Tibetan Works & Archives.
10. Ibid.
11. Archung Lama and Gega Lama. 1993. Personal communication. Kathmandu, Nepal.
12. Jackson, op. cit., 177.
13. Ibid.
14. Palache, op. cit., 543.
15. Jackson, op. cit., 78.
16. Ibid., 176.
17. Gettens, R. J., and G. L. Stout. 1966. *Painting Materials: A Short Encyclopaedia*. New York: Dover Publications, Inc., 120.
18. Kocharov, op. cit.
19. Megmar. 1993. Personal communication. Dharamsala, India: Library of Tibetan Works & Archives.
20. Jackson, op. cit., 82.
21. Palache et al., op. cit., 268.
22. FitzHugh, E. W. n.d. Orpiment and realgar. In *Artist's Pigments: A Handbook of their History and Characteristics*, Vol. III. Forthcoming.
23. Jackson, op. cit., 176.
24. Ibid., 80.
25. Ibid., 174.
26. *Makaras* are mythological sea creatures. *Garudas* are guardians of the sky (part bird and part human).
27. Jackson, op. cit., 92.
28. Kocharov, op. cit.
29. Wallert, A. 1986. Fluorescent assay of quinone, lichen, and redwood dyestuffs. *Studies in Conservation* 31 (4):145-55.
30. Jackson, op. cit., 113.
31. Ibid., 93.
32. Ibid., 81.
33. Ibid., 82.
34. Paintings at LACMA were surveyed with an infrared TV camera, Quantex QVC 2500, equipped with a bandpass interference filter (1.6 micron wavelength) to eliminate chromatic aberrations of the lenses.
35. Kossolapov, A. J. 1993. An improved vidicon TV camera for IR-reflectography. *ICOM Committee for Conservation Preprints*, 25-31.

Abstract

Icons preserved in the Nile valley are the least known of Egypt's antiquities. In the gap between the early Coptic icons from the fourth to sixth centuries and those of the second half of the eighteenth century, a recently discovered group of medieval icons that are difficult to date and attribute has assumed prominence. Two beam icons, painted on similarly made panels of sycamore timber, were selected to describe in detail. Even preliminary research on their technology has resulted in new material for the study of icon painting and the continuity of historical Egyptian techniques, materials, and mythology into Christian times.



Figure 1. Detail of the reverse side of beam B. Photograph by Z. Skalova.

New Evidence for the Medieval Production of Icons in the Nile Valley

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Introduction

Even the earliest preserved Coptic icons demonstrate that they were created for monastic circles. They repeatedly portray local saints (often monks) or they express the doctrines of Coptic religious thought. This monastic patronage remained constant.

Many Coptic icons were until recently in a poor state of preservation. Today, only a small number of icons in the Nile valley are restored to their full advantage (1). Consequently, few art historians have looked for old icons or recognized them (2). However, important medieval icons hanging in the church of St. Mercurius Abu's-Saifain in Old Cairo were admired and quite correctly assessed by Alfred Butler during the 1870s. Although they were "dim with age and indistinguishable," he concluded that "the icons generally speaking are ancient and well executed." Butler's comments on the disfigurement of the pictures caused by remarkably careless technology, when compared with Italian panels, can serve as the point of departure for this study (3).

During the last five years, the author has found, studied, and in some cases restored, some twenty medieval icons, which can be preliminarily dated between the thirteenth and the fifteenth centuries. They are nearly all large icons, clearly made for public veneration in Eastern churches. Some of these reflect distinct Coptic patronage through their iconography (4).

In assembling and attributing the group, the author relied primarily on technical aspects emphasizing the icons' kinship, which clearly shows that they emerged from the same local tradition of workmanship. Common features include the use of indigenous wood (usually sycamore), the awkward construction of the panels, a ground layer containing anhydrite, a limited range of pigments, the use of low-quality azurite blue, an unburnished golden background, and a thin gray layer of varnish (5).

Stylistic and iconographic aspects are more hybrid, but also reflect a rather peripheral and culturally mixed background. This suggests that local craftsmen and foreign painters were working together in Egypt. Thus, though these paintings are varied in style, the panels have such consistent parallels in the choice of wood and peculiar carpentry, that they can be classified together. They are manufactured from narrow, roughly assembled planks held together with huge traverses and narrow boards, and nailed with big iron nails driven in from the front. The rifts between the planks are filled on both sides with plaster and covered with palm bark fiber, and sometimes textiles, to smoothen the surface (Fig.1). When compared with panels attributed to the Greek icon workshops, they appear clumsy and extremely heavy to transport, a fact that would additionally testify to local provenance. The choice of omnipresent sycamore wood might have been dictated by scarcity and the costs of more suitable material in the Nile valley (6).

The finish of the back sides of these paintings is also characteristic for the group. They were invariably covered with a thick layer of plaster, decorated with alternating lines of wavy pink-brown and gray-blue brush strokes. This is a rare feature in icon painting, and it may suggest the formula of a work-



Figure 2a, b. One of two cuts, top, showing medallions of an archangel and an Old Testament prophet; and Blessing Christ, depicted in the central medallion, below. Photographs by Z. Skalova.

shop. Dissemination of such formulae may even have caused decoration of this type to occur on the back sides of icons in the collection of St. Catherine's Monastery at Sinai (7). However, these Sinaitic panels are skillfully made from imported wood; and they are analogous to many Byzantine icons preserved in Europe, rather than to the Coptic icons (8).

The icon supports in the Nile valley must have been made according to a different studio tradition. According to their technology, they clearly fit into the context of native (presumably Coptic) practice. Furthermore, the majority of the previously mentioned technical characteristics can be traced back to the industries and materials of Graeco-Roman and Pharaonic Egypt (9).

Two medieval beam icons

Two unique beam icons in the church of St. Mercurius Abu's-Saifain may be singled out for discussion. This church was the seat of the Coptic patriarchy in the Middle Ages and it is likely that both sacred pictures were made for it (10).

The first icon, *The Virgin with Child Enthroned between Archangels, Nine Church Fathers and Nine Coptic Monks*, measures 44.5 × 246.5 cm, and is shown in Plate 17 and Figures 3 (left) and 4a, b. The second icon, *Six Equestrian Saints* (originally ten saints), measures 45 × 207.5 cm and is shown in Plates 18a, b and in Figures 2a, b; 3 (right); and 4c–e. The two icons will be referred to here as beam A and beam B, respectively.

Thanks to Butler's description and drawing, the conservation history of these two icons can be traced back more than a century (Fig. 3). Both icons were repeatedly restored. Beam A is preserved in its original form, which has helped in reconstructing the structurally altered beam B. Butler counted only four horsemen in beam B (Fig. 3, right). Today, remarkably, beam B consists of six horsemen. Some time in the past, this longitudinal icon was cut into pieces. Meanwhile, two more horsemen from the original beam were added to Butler's fragment (Figs. 2a, 4c).

The equestrian saints are depicted in sculptured and gilded arches that carry eleven alternating medallions with Old Testament prophets, archangels, and the blessing Christ. Each horseman is identified by inscriptions in Coptic and Arabic.

Additionally, the symmetry of beam B is marred by the fact that the six holy horsemen are riding in conflicting directions. It is obvious that their initial order and number have been changed. Two cuts, visible in the restored panel, confirm this observation (Fig. 4c). Such an intervention must have been the work of a person who failed to understand the symbolism of this picture. It seems unlikely that these saints were arranged to gallop away from the Savior instead of toward him, as is proper in a hieratic composition. Christ, depicted *en buste* in one of the medallions, can be seen on Butler's fragment (Fig. 2b).

If the placement of Christ's medallion is accepted as being in the middle of the beam icon, the number of horsemen comes to ten. When reconstructed, beam B should be about 350 cm long (Fig. 4e). Clearly, both beams were conceived together to form part of broader didactic program.

A peculiar aspect of both paintings is their carpentry. They are assembled from irregularly cut horizontal pieces, three across the width and nine across the length (Figures 4b and 4d). Additional sculptured arches are nailed on the front. On the reverse, vertically placed traverses hold the planks together. Both

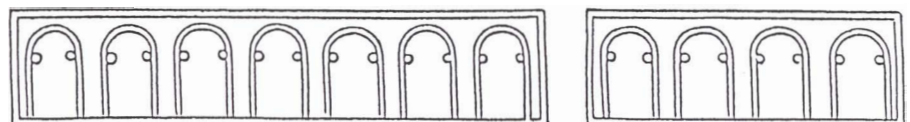


Figure 3. Beam A (left); beam B (right). Drawing by Alfred Butler, 1884.

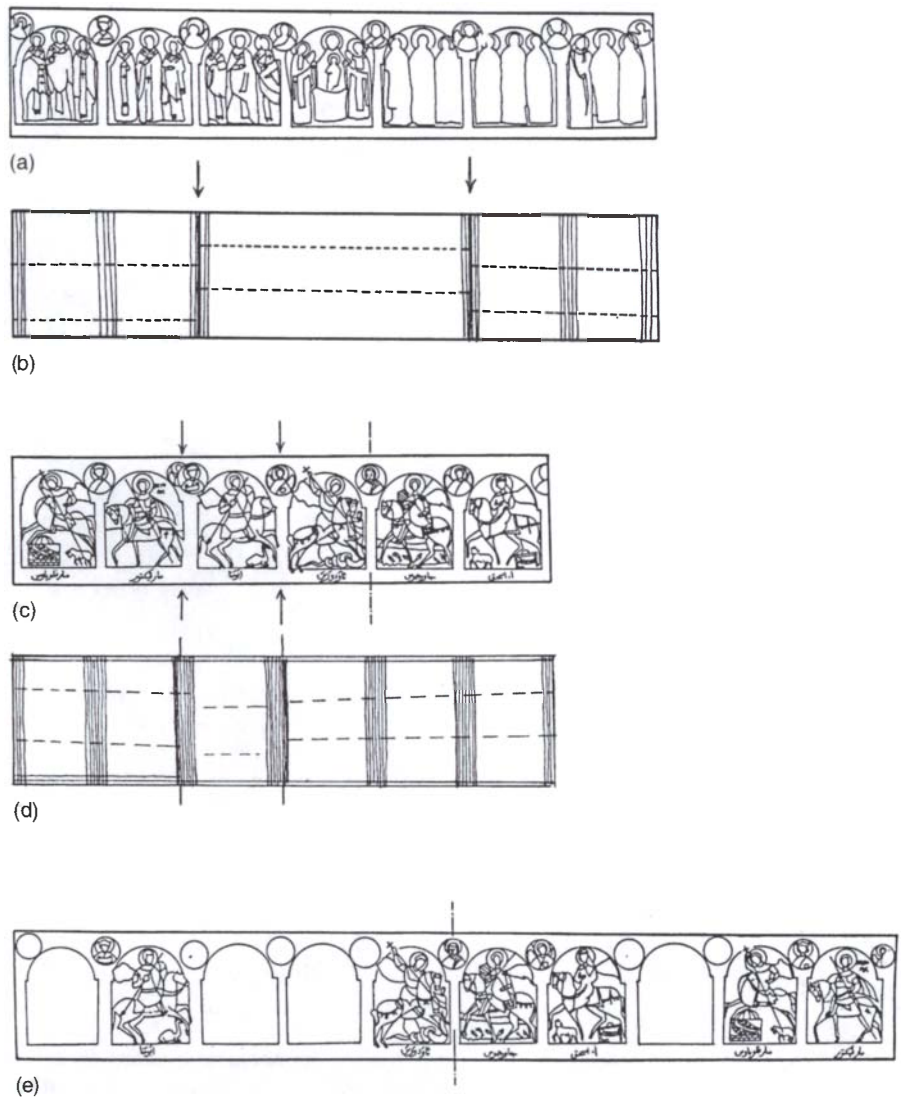


Figure 4a. Beam A, front. Drawing by Sameh Adly.

Figure 4b. Beam A, reverse. Drawing by Sameh Adly.

Figure 4c. Beam B, front. Drawing by Sameh Adly.

Figure 4d. Beam B, reverse as preserved today. Drawing by Sameh Adly.

Figure 4e. Beam B, reconstructed. Drawing by Sameh Adly.

beam icons in the church of St. Mercurius Abu's-Saifain are not only constructed from planks of the same irregular dimensions, but the wood looks so similar that it could come from one tree. The wood was identified as sycamore (*Ficus sycomorus* L.): the traverses are made from cypress (*Cupressus sempervirens* var. *horizontalis* Gord.) (11).

The Egyptian sycamore tree

The peculiar shape and dimensions of the support planks of the beam icons A and B might have been dictated by the diameter of the tree trunk that provided the timber. It does not seem probable that the patron of such significant icons would economize on the timber. The choice of painter and quality of materials usually testify to the resources and intentions of the client.

For the art historian, the interest of this research lies not only in the date and provenance of the wood (provide by dendrochronological tests), but mainly in the reason why sycamore timber was preferred (12). The use of sycamore for these icons might have derived from the holy attributes of the tree, which would have been of great importance to the patron.

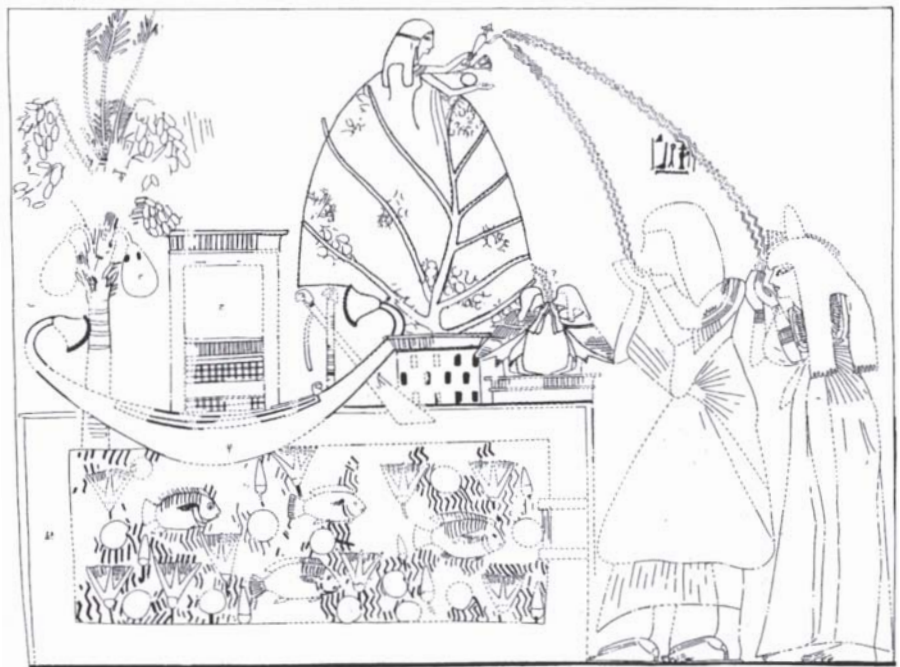


Figure 5. One of many scenes from Pharaonic tombs: an image of the tree goddess pouring blessings on the deceased. Under the sycamore's shadow are the souls of these deceased in the form of Ba birds. After N. de Garis Davis's *Seven Private Tombs at Kurnah. Mond Excavations at Thebes II. 1948. Ed. A. H. Gardiner. London, plate XXXIV.*

The symbolic importance of the sycamore tree for Copts originates in Luke 19:4, where the sycamore tree was said to have been climbed by Zachaeus in his eagerness to see Christ. In Coptic folklore, the sycamore apparently symbolizes the Coptic people (13). This suggests strong continuity with the traditional worship of the sycamore.

In ancient Egypt, the sycamore was so common that one of the names of Egypt was “Land of the Sycamore” (14). It was considered the most holy tree, thanks to the deep shadow its protective crown offered in this sunny country. Hathor, Nut, and Isis—the three ancient goddesses—were believed to dwell in the sycamore and were often depicted nestling in its crown, mostly as a personification of the tree itself (Fig. 5) (15).

The Pharaonic sycamore cult seems to have survived into local Christian mythology (16). Even today, people do not like to cut old sycamore. The tree grows in village cemeteries to provide protective shadow. Associations with the Virgin Mary resting in Egypt under the sycamore also remain alive to this day. At the well at Matariyya in Heliopolis, today a suburb of Cairo, a centuries-old sycamore still grows that is believed to have been visited by the Virgin with the infant Jesus. This holy place is abundantly described by many pilgrims as having contained, through the Middle Ages, an enchanting orchard of balsam and other exotic trees, such as cypresses (17).

Christian Ethiopia, which is closely connected with Coptic Egypt, still believes that in each sycamore one Maria lives; they call the sycamore Marianet. The link between the ancient Egyptian goddess Hathor, Lady of the Sycamore, and Christian Virgin Mary can be surmised (18).

Conclusion

In Egypt, image veneration and sycamore tree veneration have been practiced since antiquity, and great importance was attached to the use of special wood for sacred images. This tradition was so strong that its survival into Coptic times is not surprising. Thus the Coptic icons are the repository of an earlier heritage.

The understanding of an icon and its appropriate restoration according to its role and spiritual meaning in the church requires not only modern conservation training and scientific apparatus, but also a certain degree of theological sensitivity and awareness. The symbolism with respect to the actual process of icon painting used to have a fundamental significance. What was common knowledge to contemporaries must be reinterpreted after centuries of oblivion (19, 20). The icon cannot be understood apart from the wider cultural and theological context to which it belongs, as local traditions differ.

With these typically Egyptian traditions in mind, the author wonders but cannot scientifically prove, if the twin beam icons might have been made from wood of an ancient sycamore from some sacred Coptic place, such as Matariyya. This would perhaps explain why the quality of timber was deemed unimportant.

The construction of panels and the use of sycamore, as well as the distinctive Coptic iconography, all strengthen the attribution of these sacred pictures to the Nile valley. Future comparative study of the ancient Egyptian beliefs and technologies, and their survival through icon painting in the Nile valley, may enrich our knowledge about one of the oldest and most conservative pictorial traditions in the world.

Acknowledgments

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Notes

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5. I am very indebted to Paolo and Laura Mora, who, when in Egypt as directors of the Conservation team of the Nefertari Wall Painting Conservation Project 1986–1992, kindly shared their experience and advised me in this matter.
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17. Zanetti, U. 1993. Matarieh, La sainte famille et les baumiers. In *Analecta Bollandiana* (111):21–68.
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19. These are concepts that belong to religious tradition and are transmitted in a way that cannot always be scientifically investigated, which should not diminish their significance. I would like to thank the priests of the church of St. Mercurius Abu’s-Saifain for their kind support in the project, as well as my senior trainees Magdi Mansour Badawy, Hanan Nairouz, and Mona Hussein, for their assistance.
20. Abu-el-Makarim, a Coptic priest from the church Harat Zuweilah in Cairo, left a manuscript dated 1206 that describes the monasteries and churches of the Nile Delta. He mentions that in the church of St. George at Netel near Port Said, one icon of St. George is painted on a piece of the very wood used to torture the martyr saint himself. See Father Samuel. 1990. Icons et iconographie en Egypte au XIIe siècle d’après le manuscrit d’Abu-el-Makarim, publié en Arabe en Caire en 1984. *Le Monde Copte*, No. 18. Limoges.

Abstract

As part of a five-year systematic survey of the techniques of English medieval wall paintings, the highly important late Romanesque and early Gothic paintings in the Holy Sepulchre Chapel in Winchester are being examined. The use of red lake in the Romanesque scheme is the earliest recorded use of this pigment in English wall painting; the identification of vivianite, now partially altered to a yellow form, is the first in any English medieval wall painting. All aspects of the technique of both schemes, including their complex laying out, pentimenti, pigments, media, and gilding are discussed in the context of contemporary European painting.

Techniques of the Romanesque and Gothic Wall Paintings in the Holy Sepulchre Chapel, Winchester Cathedral

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Introduction

The exquisite Romanesque and Gothic paintings in the Holy Sepulchre Chapel constitute what is arguably the finest medieval painted interior in England. Dating from circa 1175 and circa 1220, respectively, their iconography and style have been discussed exhaustively by Park (1). From the technical point of view, they provide fascinating insight into the execution of two schemes of exceptionally high quality, separated in date by scarcely forty years, but painted in very different techniques. Although the technique of the earlier decoration is rooted in the tradition of painting *a fresco*, an additional proteinaceous binding medium and also lead pigments have been identified, which, together with the sweeping compositional changes made at an advanced stage of the painting process, suggest that significant portions were completed *a secco*. The Gothic painting is perhaps more typical of English medieval wall painting; though carbonation of lime is still the principal mechanism of binding, the use of large plaster patches, inclusion of additional organic binding media, and incorporation of pigments unsuitable for application in alkaline conditions preclude describing the technique as fresco.

Investigation of the painting technique was undertaken as part of a comprehensive five-year study, funded by the Leverhulme Trust, of English medieval wall painting techniques and in conjunction with a conservation campaign in the chapel undertaken by the Courtauld Institute of Art and sponsored by the Skaggs Foundation (2).

The paintings

The most striking area of late twelfth-century painting is on the east wall of the Chapel, comprising a *Deposition* in the upper register and, below the dividing geometric border, an *Entombment* with the *Maries at the Sepulchre* and the *Harrowing of Hell*. Uncovered when the overlying thirteenth-century scheme was detached in the 1960s, the painting has escaped the ravages of multifarious conservation treatments to which it would almost certainly have been subjected had it been exposed earlier. The surface was severely keyed in preparation for the thirteenth-century plaster, but despite these numerous damages the superb quality of the painting is evident (Fig. 1 and Plate 19). Traces of the Romanesque scheme survive elsewhere, as on the south wall above the western recess where a *Resurrection of the Dead* with an angel blowing the last trumpet is positioned on either side. Originally situated in the corresponding position above the eastern recess, but now transferred to the north wall of the chapel, is a striking mitered head and a *sinopia* for three scenes set under architectural canopies. To date, this *sinopia* is a unique find in the context of English medieval wall painting, and provides important evidence for the technique of the Romanesque scheme.

Extensive remodeling of the chapel in the early thirteenth century, including the insertion of a rib vault, destroyed large portions of the Romanesque scheme and necessitated a complete redecoration. The resulting scheme is also of exceptionally high quality, but has been marred by a series of invasive conservation treatments. The painting originally decorating the east wall (and

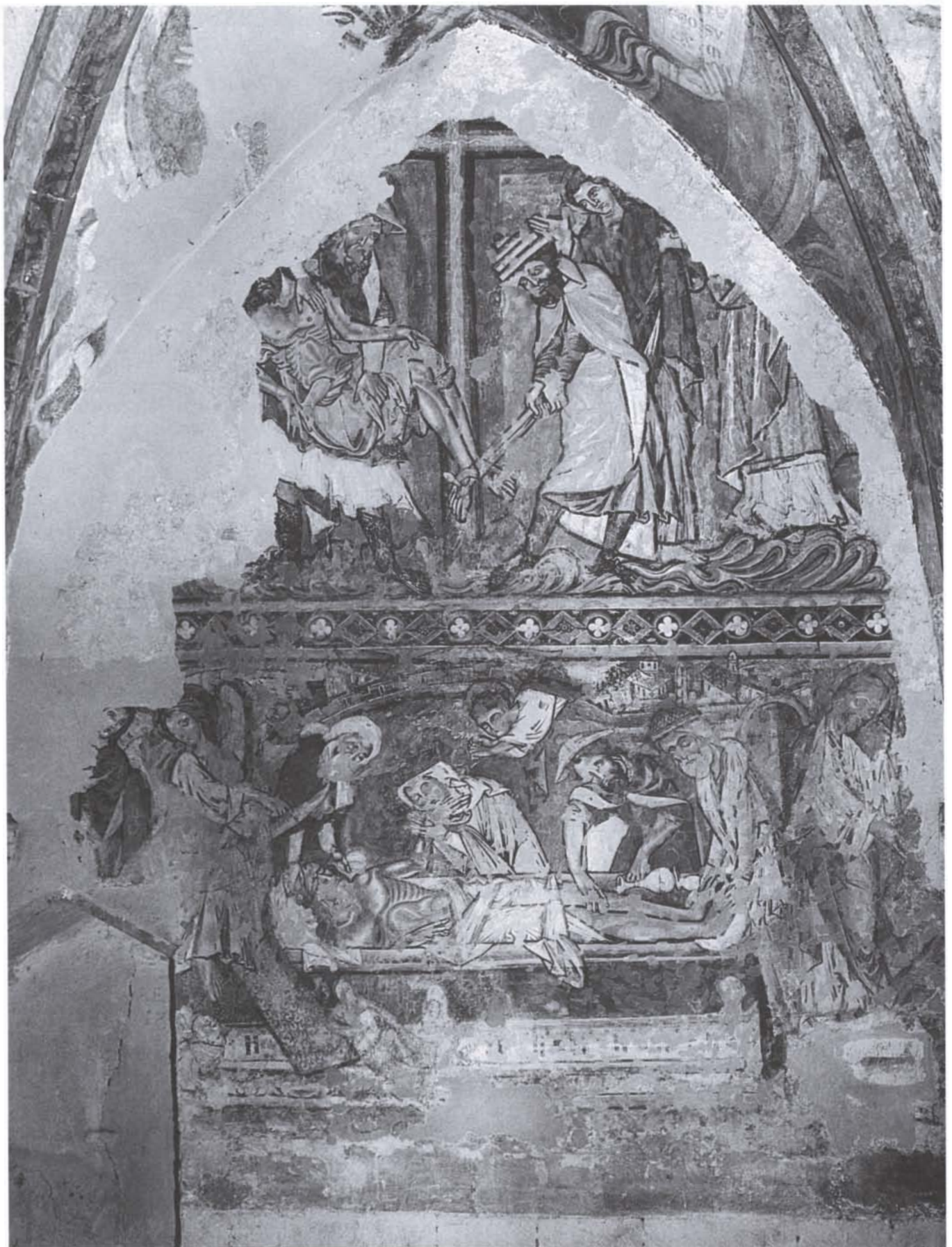


Figure 1. Holy Sepulchre Chapel, Winchester Cathedral. General view of the twelfth-century painting on the east wall. Photograph courtesy of the Conservation of Wall Painting Department, Courtauld Institute of Art, London.

later transferred to an artificial support at the west end of the chapel) mirrored the iconography of the Romanesque painting beneath with a few minor adjustments. The Magdalene in the *Deposition* was replaced by a centurion holding a scroll, and the *Harrowing of Hell* was moved to the recess of the adjacent south wall and paired with the *Noli me Tangere*. Above this recess is the *Entry into Jerusalem* and a newly identified scene of the *Washing of Christ's Feet* (3). Within the western recess of the south wall are scenes of the Martyrdom of St. Catherine of Alexandria. A striking image of Christ as *Pantocrator*, surrounded by evangelist symbols, fills the eastern segment of the vault, while the remaining segments are painted with *Infancy* scenes (*Annunciation*, *Nativity*, and *Annunciation to the Shepherds*), foliage, and busts in roundels. Other thirteenth-century painting survives on the northern arches of the chapel.

Conservation history

Until the conservation program in the 1960s, very little of the twelfth-century painting was visible, as it lay beneath the later scheme. The thirteenth-century painting was itself in extremely poor condition, due to the combination of humidity and the wax coating and hair nets applied by Professor Tristram in the 1920s to consolidate the surface (4). The conservation campaign in the 1960s involved the following: transfer of the thirteenth-century painting on the east wall to an artificial support at the west end; detachment and replacement in situ of other areas of thirteenth-century painting; transfer of the mitered head and sinopia from the twelfth-century scheme onto the north wall; partial removal of the wax coating; and consolidation with skimmed milk and lime water. This complex conservation history has far-reaching implications for the conclusions that can be drawn for the original technique of the thirteenth-century paintings.

Technique of the twelfth-century painting

Plaster. Information on the construction mortar, depth, and stratigraphy of the Romanesque plaster is largely concealed by edging repairs and fills. There are, however, two areas which supply valuable evidence for the original technique. The ashlar support is visible at dado level where the plaster has been lost, and it is clear that a single plaster layer approximately 0.5 cm in thickness was applied to the stone. Elsewhere there are two distinct plaster layers: the uppermost layer, the *intonaco*, is approximately 0.5 cm in thickness, while below that a slightly coarser and more yellow plaster appears to be about 1.0 cm thick. It seems reasonable to assume that a layer of plaster was applied to level the masonry where necessary, and that the *intonaco* was then either applied over this, or directly on to the stone.

Unfortunately, it was not possible to take a sufficiently large sample for full analysis of the original plaster, but from visual examination of the polished cross sections it was estimated that a finely graded inert aggregate, principally subangular quartz, was combined with lime in a ratio of approximately 2:1 to create the *intonaco*. The conspicuous addition of chopped straw and fibers to the plaster suggests that they were included to increase the mechanical strength of the render. This organic material may have had the additional function of acting as a mechanical buffer by absorbing moisture during the setting of the plaster (5). In some samples, it is also clear that charcoal particles have been incorporated, with the greatest concentration beneath areas that are predominantly blue (Plate 20, samples 3 and 5). It seems likely that the charcoal was incorporated to reduce the light scatter from the white substrate, thereby increasing the covering power of the blue mineral pigments.

Although the surface texture itself is fairly smooth, the overall topography of the painted surface is remarkably uneven. The application of the plaster is rather crude, with deep undulations readily visible in raking light (6).

There are two principal horizontal zones of plaster corresponding to the narrative registers, and another for the ornamental border that divides these

registers (Fig. 2). Additionally, within each of the principal plaster zones, there are further divisions that roughly conform to the various individual figures or groups of figures. These secondary plaster joins, many of which are rather indistinct (particularly in the lower register) make an understanding of the plastering sequence problematic. It is evident however, that the narrow central plaster patch for the geometric border was applied before the plastering of either narrative register. In the upper register, the roughly executed plaster joins, applied wet-over-dry, clearly indicate that the patch for the central cross was applied first, followed by that for the main figure group, and finally those for the flanking figures. By contrast, the plaster joins in the lower register are indistinct, and the application appears to have been wet-on-wet, allowing the edges to merge. Careful examination of the surface in raking light does, however, indicate that the central portion may have been applied first.

The plastering of the east wall of the chapel differs significantly from that typically found elsewhere in England, where accumulated evidence at Kempley, Witley, and Canterbury suggests that application in broad horizontal bands is characteristic of the Romanesque period (7). The plaster patches at Winchester do, however, find parallels both in England and on the Continent: in the scheme (ca. 1100) in the parish church at Hardham (Sussex), where separate plaster patches were applied for each scene as well as for the borders; and in the Romanesque paintings of Vicq (France), in which the plaster was applied in a grid of large rectangular patches corresponding to the narrative and ornamental divisions (8, 9).

Preparatory techniques. The detachment of a portion of the thirteenth-century scheme from the south wall in the 1960s provided particularly significant information concerning the laying out of the Romanesque painting. A small but exquisite mitered head was uncovered here; underneath was found a sinopia for three scenes set beneath architectural canopies.

The existence of a sinopia on the east wall, traces of which are visible where tiny losses in the intonaco exist, was noted by Park (10). Evidence from the stratigraphy of the plaster and from the examination of cross sections, such as that of Sample 29 showing a trace of red pigment (red earth with some cinnabar) beneath approximately 0.4 cm of plaster, suggests that the sinopia was applied either directly on the ashlar support or leveling plaster.

Examination of the surface of the Romanesque plaster in raking light reveals the use of snapped lines marking the position of the central ornamental border. The geometric elements within the border were set out by incision into the wet plaster with the aid of a compass. When this border was moved to a slightly lower position, new incisions were made, but in this case a slightly different quality of line is evident since the plaster was clearly no longer as fresh. Incision into the wet plaster is evident in other distinct areas, as in Christ's arm and the flagon of holy oil in the *Entombment*. In addition, a preparatory drawing in yellow iron oxide, clearly visible wherever the paint layers have been lost, was used to place the main pictorial elements within the visual field.

Pentimenti. The Romanesque paintings are particularly fascinating from the point of view of the changes made by the painter at an advanced stage of the painting process. This is particularly evident in the *Entombment*, in which the remains of another head and a broad-brimmed hat can just be seen to the left of the Virgin's head, indicating the original position of the figure anointing Christ's body with oil (in the final version placed to the right of the Virgin).

Many other alterations are visible. For instance, the figure of St. John in the *Deposition* was finally painted with his hand gesturing toward Christ, but the yellow preliminary drawing indicates that he was originally conceived with his hand held to his face in grief.


Palette. The present research has established that the palette of the Romanesque paintings included: gold leaf, Au; natural ultramarine,


Winchester Cathedral Holy Sepulchre Chapel

0 20 40 60 80 100 cm

East Wall



 Incisions

 Snapped Lines

 Plaster Joins

Figure 2. Diagram of the east wall scheme, showing the position of plaster joins, incision, and snapped cord marks. Diagram courtesy of the Conservation of Wall Painting Department, Courtauld Institute of Art, London.

$3\text{Na}_2\text{O}\cdot 3\text{Al}_2\text{O}_3\cdot 6\text{SiO}_2\cdot 2\text{Na}_2\text{S}$; vivianite $\text{Fe}_3 + 2(\text{PO}_4)_2\cdot 8\text{H}_2\text{O}$; cinnabar, HgS ; red lake; red lead, Pb_3O_4 ; hematite, Fe_2O_3 ; green earth, $\text{K}[(\text{Al}, \text{Fe}^{\text{III}})\cdot (\text{Fe}^{\text{II}}, \text{Mg})]\cdot (\text{AlSi}_3, \text{Si}_4)\text{O}_{10}(\text{OH})_2$; yellow iron oxide, $\text{Fe}_2\text{O}_3\cdot \text{H}_2\text{O}$; and lime white, CaCO_3 .

One of the most interesting findings is that red lake was used for the unusual pink color of Nicodemus's robe. This is the earliest identification of this pigment in English wall painting, though at Müstair (Switzerland) a red lake pigment thought to be madder has been identified in the Carolinian scheme of circa 800 (11).

The inclusion of vivianite in the palette is particularly surprising, not only since this pigment has not previously been identified in English medieval wall painting, but also because it was clearly selected for its distinctive coloristic qualities rather than as an economic alternative to other mineral blues (12). The characteristic deep indigo blue of vivianite, set against a pale blue of natural ultramarine combined with lime white, was employed for the central details on the vair (bluish gray and white squirrel fur) lining of Nicodemus's cloak in the *Deposition*. Although the iron phosphate mineral has now altered and appears green, an examination of the Morgan leaf from the Winchester Bible (ca. 1170–1180) shows that vair linings were represented by pale blue elements with a dark blue center, and it is clear that this was also the intention in the wall paintings.

Binding media. Analysis undertaken initially by microchemical tests on thin sections and cross sections was followed in some cases by Fourier transform infrared microspectroscopy. Results confirmed that although the carbonation of lime is the principal binding mechanism, a proteinaceous component is also present in some samples. A proteinaceous component was identified, for example, in a paint layer consisting of red lead, lead white, and calcium carbonate in Sample 27, taken from the impasto decoration of the geometric border. Likewise, a proteinaceous component was identified in a layer of calcium carbonate applied beneath a resinous mordant for gold leaf in Sample 30, from the halo of the angel in the *Entombment*.

Instrumental analysis of the media of comparable wall paintings is rare, but it is significant that, where available, it indicates similar findings. For instance, in the paintings (ca. 1130) of Idensen (Lower Saxony), the presence of a proteinaceous binding medium is associated with blue and green pigments, while in the scheme (ca. 1130) in St. Gabriel's Chapel, Canterbury Cathedral, both linseed oil and protein have recently been identified as part of the original technique (13, 14).

Application. The presence of a sinopia, and the application of the intonaco in overlapping patches, indicate that the primary binding mechanism for the pigments was the carbonation of calcium hydroxide from the lime plaster; that is, at least the preliminary drawing and initial pigment layers were applied *a fresco*. However, the stratigraphy of the final painting is remarkably complex and varies substantially across the pictorial surface, from thin single layers applied directly on the lime plaster substrate to paint applied in considerable impasto, often over colored grounds (Table 1). In Sample 24, a single layer, just 30 μm thick, of yellow iron oxide combined with umber and a few charcoal black particles has been applied directly to the white plaster substrate. Layers such as this are likely to have been applied *a fresco*. For areas of flesh painting, multiple layers have been applied to produce complex effects of modeling. In Sample 7, the mid-dark flesh tone has been produced by the application of five different layers of earth pigments—green, red, and yellow—applied either singly or in combination, often with the addition of lime white and charcoal black. Here, carbonation of the lime white pigment provides additional binding capacity within the complex layer structure. By contrast, red lead combined with an additional proteinaceous binding medium was applied in a layer some 200 μm thick for the decorative motifs on the central border, over a thin layer of carbon black applied directly to the lime plaster.

Gilding. Gold leaf was applied for a small number of particular features such as halos and the decorative borders of drapery. Two samples were taken to establish the gilding technique; in both cases, analysis by FTIR indicated that a resinous mordant was used to adhere the gold leaf. The supporting layer consists of calcium carbonate combined with a protein, probably glue. At 5 μm , the gold leaf is exceptionally thick, more than twice that found at Iden-sen (1–2 μm) where it was applied over a “bole” of lead white and carbon black bound with prepolymerized linseed oil (15).

Fading of the lake pigment. Although the susceptibility of red lakes to fading was known in the Middle Ages, they were nonetheless often used in wall paintings (16). The key factor in the fading of lake pigments is exposure to ultraviolet radiation, and, indeed, a darker pink is apparent where fresh losses have occurred in linear details overlaying Nicodemus’s drapery. Lake pigment mixed with white, applied over a white ground and unprotected by a glaze (i.e., the Holy Sepulchre Chapel paintings), is particularly vulnerable to internal reflection (17).

Alteration of vivianite. Initial identification of the pigment by polarized light microscopy, in which the pigment is typified by blue–yellow pleochroism every 90° , was confirmed by X-ray diffraction (18, 19). In recent years, vivianite has been identified in medieval painting in Germany, as on the Romanesque lectern at Freudenstädter (ca. 1150) where it was applied over a gray ground of lead white combined with carbon black (20). In the context of English medieval polychromy, a preliminary identification of the mineral has been made on an Anglo-Saxon stone sculpture from York (21).

Vivianite occurs naturally in two discrete environments. It is found in the oxidized upper layers of some metalliferous ore deposits, as at St. Agnes in Cornwall, where it generally appears as dark indigo, blue-black, or green crystals (22). It is also found in organic, phosphate-rich environments, and is frequently associated with bones, decaying wood, and other organic remains. Vivianite is generally stable and dark blue or green in color, though the mineral may be colorless when initially exposed (23).

It seems likely that in the medieval period vivianite was used only where the mineral was locally available; thus, mineral deposits are well known in Germany. Good crystalline deposits of the mineral have been found at Whale Chine on the Isle of Wight, and in its earthy form at Fordingbridge in Hampshire, both close to Winchester (24). Current work on samples from the chapel includes an analysis of trace elements and examination of the crystalline structure to determine whether a mined or peaty alluvial deposit was the source of the mineral.

Vivianite is known to be generally stable in its blue form but at Winchester some of the particles have altered to a yellow color, giving an overall green effect. The mineral’s color change from colorless to blue on initial exposure is due to increased ferric ion concentrations, and it has been established that mechanical grinding of the colorless crystals, heating in air, storage in a vacuum, or chemical treatment of samples can produce a more rapid conversion from ferrous to ferric ions, and so to a blue color (25, 26). It is therefore interesting to speculate whether grinding of the blue mineral to produce a particle size suitable for use as a pigment may have contributed to an additional increase in ferric ion concentration and ultimately to a further color alteration from blue to yellow.

Technique of the thirteenth-century paintings

Invasive conservation interventions—including waxing, facing with glue for detachment, thinning of the original plaster support, consolidation, and cleaning—have compromised the results of the technical examination of these paintings. Nevertheless, certain conclusions can be drawn.

Plaster. Following the keying of the twelfth-century painting, a single layer of plaster approximately 5–8 mm thick was applied to the surface. This



Figure 3. This thirteenth-century painting, originally on the east wall, has been transferred to an artificial support at the west end of the chapel. Photograph courtesy of the Conservation of Wall Painting Department, Courtauld Institute of Art, London.

Winchester Cathedral Holy Sepulchre Chapel

0 20 40 60 80 100 cm

West Wall



 Plaster Joins

Figure 4. Diagram of the thirteenth-century east scheme (now transferred to the west end), showing the position of plaster joins. Diagram courtesy of the Conservation of Wall Painting Department, Courtauld Institute of Art, London.

plaster consists of lime combined with an aggregate of subangular quartz in a ratio of 1:3. It is generally more yellow and less well prepared than the plaster for the earlier decoration, with large lumps of unmixed calcium carbonate clearly visible.

It is now difficult to establish the sequence of application of the plaster, since surface features have been completely flattened by the detachment process (Figs. 3, 4). Examination under raking light of the surface of the east wall paintings (now transferred to the west end) does, however, indicate that plaster joints may originally have run along the upper edge of the central border and the lower horizontal of the cross in the upper register. This indicates that generally the plaster may have been applied in broad horizontal bands, roughly corresponding to scaffold lifts. However in the east recess of the south wall there appears to be a vertical joint between the *Harrowing of Hell* and *Noli me Tangere*, suggesting that in this area at least a further division was considered necessary.

Preparatory techniques. A preparatory sketch in red iron earth was used to set out the main features of the composition. Unlike the twelfth-century painting wherein both a sinopia and then further preparatory drawing on the final plaster layer exist, in the thirteenth-century scheme the preparatory drawing is confined to the final plaster layer.

Direct incisions into the plaster are also clearly visible, such as the fine, sharp incisions that outline the curls in the hair of the figure at far right in the *Entombment* and the hair of St. John in the *Deposition*.

Pentimenti. An interesting alteration discovered during the detachment process—and presumably visible on the reverse of the thinned plaster layer—was that above the horizontal arm of the cross in the *Deposition* was a sketch for the sun and moon, which are symbols more usually associated with the *Crucifixion* (27).

Pigments. The present research has established that the original palette included: natural ultramarine ($3\text{Na}_2\text{O}\cdot 3\text{Al}_2\text{O}_3\cdot 6\text{SiO}_2\cdot 2\text{Na}_2\text{S}$); vivianite ($\text{Fe}_3 + 2[\text{PO}_4]_2\cdot 8\text{H}_2\text{O}$); copper chloride green; cinnabar (HgS); hematite (Fe_2O_3); yellow iron oxide ($\text{Fe}_2\text{O}_3\cdot \text{H}_2\text{O}$); lead white ($2\text{PbCO}_3\cdot \text{Pb}[\text{OH}]_2$); lime white (CaCO_3); charcoal black (C).

Binding media. The inclusion of lead pigments in the palette makes highly likely the incorporation of organic binding media as part of the original technique but, owing to the previous conservation interventions, it was not possible to confirm their presence.

Application. Preliminary drawing in red ochre was followed by blocking in of the basic background colors. Oakeshott considered that the powerful black outlines, which are such a major feature of the scheme, were also painted at this stage and were thus more firmly bound by the carbonation of the plaster (28). The stratigraphy is remarkably simple, with one or at most two paint layers applied directly to the plaster (Tables 2, 3, 4, 5). In some cases the final paint layer was applied in thick impasto, and it seems likely that here an additional binding medium was used.

Pigment alteration. Although the background colors of the scheme are now red and green, it seemed much more likely on the basis of comparisons with other paintings of the period that red and blue would originally have been used. Analysis indicated that this was indeed the case: the present green color is due to the alteration of some of the original blue pigment (vivianite) to form a yellow alteration product.

The alteration of a lead pigment is evident in the form of black spots on the paint surface throughout the scheme, and analysis confirmed the presence of a dark red/brown lead-based material. In wall paintings elsewhere where this type of alteration occurs, the alteration product has been found to be plattnerite (lead dioxide) (29). In the Holy Sepulchre Chapel however, analysis by

scanning electron microscopy/energy dispersive spectroscopy (SEM/EDX) analysis indicated a low oxygen peak, which may indicate that a mixture of lead dioxide and lead sulfide is present here. In addition, cinnabar has altered to its dark form, metacinnabar, as shown in Sample 37, taken from the darkened cheek patch of a prophet on the vault.

Acknowledgments

I am grateful to the Leverhulme Trust for their generosity in funding the five-year study, and to the Skaggs Foundation for their support of the conservation program at Winchester. Particular thanks are also due to G. Cressey and P. Tandy of the Natural History Museum, and to David Park, Sharon Cather, and Robyn Pender of the Conservation of Wall Painting Department, Courtauld Institute of Art.

Table 1. Samples from the east wall of the Holy Sepulchre Chapel, Winchester Cathedral

Sample No:	Location and Description	Original Polychromy	Indications of binding media/Pigment alterations and other additions
3	E. wall, upper tier, S. side, olive green background to left of Nicodemus' foot.	<ul style="list-style-type: none"> vivianite 20µm natural ultramarine 30µm lime plaster with charcoal black inclusions 400µm 	<ul style="list-style-type: none"> vivianite has partially altered from blue to yellow
4	E. wall, upper tier, S. side, red background adjacent to cross, red over blue.	<ul style="list-style-type: none"> cinnabar in red lead matrix with a few particles of natural ultramarine 220µm natural ultramarine 30µm 	<ul style="list-style-type: none"> calcium carbonate crust on surface
5	E. wall, upper tier, N. side, uppermost edge of Joseph of Aramathia's hat, grey surface over red pigment on blue.	<ul style="list-style-type: none"> cinnabar 10µm natural ultramarine and charcoal black in a lime white matrix 10µm lime plaster with charcoal black inclusions 250µm 	
6	E. wall, upper tier, N. side, Joseph of Aramathia's red drapery, translucent dark red shadow just below beard.	<ul style="list-style-type: none"> haematite 20µm yellow iron oxide 2µm trace calcium carbonate cinnabar 55µm lime plaster 100µm 	
7	E. wall, upper tier, Christ's right foot, mid-dark flesh tone.	<ul style="list-style-type: none"> red, yellow and green iron oxides and charcoal black 10µm green iron oxide 45 µm lime white combined with yellow iron oxide 100µm yellow iron oxide 25µm red iron earth 50µm trace lime plaster 	
8	E. wall, upper tier, Nicodemus' pink drapery, at hip level, pale pink with highlight.	<ul style="list-style-type: none"> red lake with a trace of ultramarine in a calcium carbonate matrix 100µm. The trace of calcium sulphate present in the layer may represent the substrate of the lake pigment, now faded. plaster substrate with charcoal black 80µm 	<ul style="list-style-type: none"> red lake pigment has faded
9	E. wall, lower tier, N. side, Joseph of Aramathia's red robe, darkest red tone at uppermost edge.	<ul style="list-style-type: none"> cinnabar 30µm yellow iron oxide 10µm plaster substrate with a few charcoal black inclusions 200µm 	
10	E. wall, lower tier, N. side, Christ's proper hand, flesh painting with pink drop of blood on surface.	<ul style="list-style-type: none"> cinnabar 20µm trace yellow iron oxide green iron oxide 45µm lime white with yellow iron oxide particles 100µm lime white, yellow iron oxide and charcoal black 60µm 	
21	E. wall, lower tier, <i>Harrowing of Hell</i> , deep purple shadow in drapery.	<ul style="list-style-type: none"> natural ultramarine, charcoal black and lime white 90µm lime white 40µm plaster substrate 200µm 	
22	E. wall, lower tier, <i>Harrowing of Hell</i> , green outer drapery (query modern retouching).		<ul style="list-style-type: none"> cobalt green (CoO·nZnO)
23	E. wall, lower tier, lower edge of sarcophagus, deep purple over yellow.	<ul style="list-style-type: none"> charcoal black, red/brown iron oxides with a few particles of cinnabar 80µm yellow iron oxide combined with lime white 90µm plaster substrate 120µm 	
24	E. wall, lower tier, Christ's loin cloth, yellow shadow over deep yellow.	<ul style="list-style-type: none"> yellow iron oxide and umber with a few charcoal black particles 30µm plaster substrate 100µm 	
25	E. wall, upper tier, Magdalene's drapery, hem at calf level, yellow & white bole over red/purple and black paint layers.	<ul style="list-style-type: none"> resinous layer 50µm white layer (calcium carbonate + protein) 30µm resinous layer 100µm white layer (calcium carbonate + protein) 20µm resinous layer 100µm 	<ul style="list-style-type: none"> a proteinaceous binding medium is present in the white layers
26	E. wall, upper tier, Nicodemus' cloak, blue and white vair lining, green area over blue.	<ul style="list-style-type: none"> vivianite in calcium carbonate matrix 90µm natural ultramarine in lime matrix 100µm plaster substrate 300µm 	<ul style="list-style-type: none"> vivianite has partially altered from blue to yellow
27	E. wall, central decorative border, 4th circular motif from north side, impasto motif in orange and white.	<ul style="list-style-type: none"> red lead combined with lead white and calcium carbonate with a trace of proteinaceous binding medium present 200µm carbon black 10µm 	<ul style="list-style-type: none"> translucent crust of calcium carbonate combined with calcium sulphate on surface a proteinaceous binding medium is present in the red paint layer
28	E. wall, upper tier, Nicodemus' right proper leg, brilliant rich red highlight over red lead and yellow earth.	<ul style="list-style-type: none"> cinnabar combined with red lead 50µm red lead 100µm 	
29	E. wall, upper tier, wavy ground between Nicodemus' legs, deep red brown over pink.	<ul style="list-style-type: none"> red iron oxide 15µm cinnabar 10µm plaster substrate/ground 400µm underdrawing, red iron oxide and cinnabar 100µm 	<ul style="list-style-type: none"> white crust on surface
30	E. wall, lower tier, censuring angel, halo, trace gilding on bole over brown paint layer and red lead.	<ul style="list-style-type: none"> gold leaf 5µm resinous mordant 20µm white layer (calcium carbonate + protein) 10µm dark resinous layer 15µm white layer (calcium carbonate + protein) 20µm dark resinous layer 25µm 	<ul style="list-style-type: none"> white crust and trace pigment on surface a proteinaceous binding medium is present in the white layers
31	E. wall, lower tier, N. side, angels' drapery, green over yellow near hem.	<ul style="list-style-type: none"> green iron oxide combined with some charcoal black particles 50µm yellow iron oxide 75µm yellow iron oxide combined with lime white 180µm plaster substrate with charcoal black particles 120µm 	<ul style="list-style-type: none"> trace white crust combined with a few charcoal black particles
32	E. wall, upper tier, N. side, grey/green background between legs of Joseph of Aramathia.	<ul style="list-style-type: none"> charcoal black with a few red and yellow iron oxide particles 80µm plaster substrate 200µm 	

The table gives the location where each sample was taken, the sample number, and the stratigraphy of the various layers from the top down, with the thickness of each layer in microns (µm).

Table 2. Samples from the west wall of the Holy Sepulchre Chapel, Winchester Cathedral

Sample No:	Location and Description	Original Polychromy	Coatings/ Indications of binding media/ Pigment alterations
34	W. wall, upper tier, N. side, green background colour below white scroll.	<ul style="list-style-type: none"> vivianite 100µm charcoal black 80µm lime plaster substrate 60µm 	<ul style="list-style-type: none"> beeswax coating containing calcium carbonate and calcium sulphate 20µm proteinaceous coating 30µm vivianite has partially altered from blue to yellow
35	W. wall, upper tier, St. John, drapery below knee, black over pink.	<ul style="list-style-type: none"> darkened lead pigment 15µm lime plaster substrate 250 µm 	<ul style="list-style-type: none"> beeswax (trace) proteinaceous coating lead pigment has altered to form a dark product which appears to be a mixture of lead dioxide (plattnerite) and lead sulphide.
36	W. wall, upper tier, S. side, (left as viewed) leg of Joseph of Aramathea, dark green linear detail on back of calf.	<ul style="list-style-type: none"> vivianite 150µm charcoal black and lime white 40µm lime plaster substrate 100µm trace of red pigment from 12th century scheme 20µm 	<ul style="list-style-type: none"> beeswax (trace) proteinaceous coating vivianite has partially altered from blue to yellow

Table 3. Samples from the north wall of the Holy Sepulchre Chapel, Winchester Cathedral

Sample No:	Location and Description	Original Polychromy	Coatings/ Indications of binding media/ Pigment alterations
11	N. wall, E arch, soffit, E. side, upper figure, left proper arm, pale pink drapery.	<ul style="list-style-type: none"> white, lead-containing pigment with charcoal black, calcium carbonate, calcium sulphate & red pigment particles yellow, lead-containing layer which appears white towards perimeter. few yellow iron oxide particles are present. lime ground - calcium carbonate with calcium sulphate and a trace of wax present 	
12	N. wall, E arch, chamfer on S. side, E end, 6th ashlar block from apex, yellow over green on plaster.	<ul style="list-style-type: none"> yellow earth pigment in lead white matrix vivianite in lead white matrix lime white ground 	<ul style="list-style-type: none"> proteinaceous coating proteinaceous material is indicated in both paint layers vivianite has partially altered from blue to yellow
13	N. wall, E arch, S face, E side, C13th vine scroll in red on plaster.	<ul style="list-style-type: none"> red earth lime ground 	<ul style="list-style-type: none"> beeswax proteinaceous coating
14	N. wall, E arch, soffit, E. side, lower figure, thick beige coating over green paint of drapery.	<ul style="list-style-type: none"> vivianite in lead white matrix 	<ul style="list-style-type: none"> beeswax proteinaceous coating thick lead white layer vivianite has partially altered from blue to yellow

The tables give the location where each sample was taken, the sample number, and the stratigraphy of the various layers from the top down, with the thickness of each layer in microns (µm).

Table 4. Samples from the south wall of the Holy Sepulchre Chapel, Winchester Cathedral

Sample No:	Location and Description	Original Polychromy	Coatings/ Indications of binding media/ Pigment alterations
16	S. wall, E. bay, above recess, blue background behind donkey's left ear, thick dark impasto over blue background.	<ul style="list-style-type: none"> darkened lead pigment 100µm natural ultramarine (25µm) 	<ul style="list-style-type: none"> proteinaceous material on surface lead pigment has altered to form a dark product which appears to be a mixture of lead dioxide (plattnerite) and lead sulphide
17	S. wall, W bay, above recess, E. side, old cleaning test area, coating from in key mark	<ul style="list-style-type: none"> organic analysis only 	<ul style="list-style-type: none"> layers of beeswax
18	S. wall, W. bay, above recess, E. side, old cleaning test area, coating over red/ brown paint layer.	<ul style="list-style-type: none"> carbon black pigment 5µm red earth in lime matrix 10µm lime ground 40µm lime plaster 200µm 	<ul style="list-style-type: none"> beeswax with a small amount of proteinaceous material
19	S. wall, W. bay, above recess, W. end, C12th angel, area fluoresces in uv, coating over black and orange paint.	<ul style="list-style-type: none"> black and red particles in a lead white matrix 35µm lime ground 140µm lime plaster substrate 400µm 	<ul style="list-style-type: none"> extremely thin coating present which is almost completely combined with the upper pigment layer. As yet unidentified
20	S. wall, W. bay, recess, lower zone, central area of dark red 'drapery', coating over red/black paint.	<ul style="list-style-type: none"> red iron oxide 25µm charcoal black 40µm 	<ul style="list-style-type: none"> beeswax
41	S. wall, E. bay, above recess, <i>Washing of feet</i> , bright green from 'border' above Christ's head.	<ul style="list-style-type: none"> blue/green copper chloride green layer 50µm paler blue/green copper chloride layer 50µm calcium carbonate with a little calcium sulphate present 20µm 	<ul style="list-style-type: none"> trace coating on surface copper chloride green may be the product of an alteration process

The table gives the location where each sample was taken, the sample number, and the stratigraphy of the various layers from the top down, with the thickness of each layer in microns (µm).

Table 5. Samples from the vault of the Holy Sepulchre Chapel, Winchester Cathedral

Sample No:	Location and Description	Original Polychromy	Coatings/ Indications of binding media/ Pigment alterations
15	Vault, E. bay, E. segment, under left proper hand of Christ, 'pea' green background of mandorla.	<ul style="list-style-type: none"> vivianite 75µm 	<ul style="list-style-type: none"> beeswax proteinaceous coating vivianite has partially altered from blue to yellow
37	Vault, E. bay, S. segment, W. side, prophet in roundel, darkened cheek patch.	<ul style="list-style-type: none"> black (darkened cinnabar) particles in lead white matrix 15µm plaster substrate 140µm 	<ul style="list-style-type: none"> proteinaceous coating with additional components of calcium carbonate, calcium sulphate and a trace of wax 15µm cinnabar has altered to its black meta form
38	Vault, E. bay, S. segment, W. side, prophet in roundel, yellow flesh painting of hand.	<ul style="list-style-type: none"> yellow iron oxide 15µm lime white ground 50µm plaster substrate 200µm 	<ul style="list-style-type: none"> proteinaceous coating 10µm
39	Vault, E. bay, S. segment, W. side, prophet in roundel, hand, dark flesh area.	<ul style="list-style-type: none"> charcoal black and red iron oxide 40µm lime white ground 100µm plaster substrate 	<ul style="list-style-type: none"> proteinaceous coating with additional components of calcium carbonate and calcium sulphate 30µm proteinaceous material has penetrated paint layers
40	Vault, E. bay, W. side, S. segment, prophet in roundel, left side, dark band around edge of roundel.	<ul style="list-style-type: none"> dark red/brown lead-based layer 65µm lime white ground 75µm 	<ul style="list-style-type: none"> proteinaceous coating 20µm lead pigment has altered to form a dark material which appears to be a mixture of lead dioxide (plattnerite) and lead sulphide
42	Vault, E. bay, S. segment, W. side, prophet in roundel, red linear detail of robe over now black layer.	<ul style="list-style-type: none"> red earth 125µm dark red/brown lead-based material 55µm white ground 75µm plaster substrate 400µm 	<ul style="list-style-type: none"> proteinaceous coating 25µm lead pigment has altered to form a dark material which appears to be a mixture of lead dioxide (plattnerite) and lead sulphide
43	Vault, E. bay, E. segment, mandorla, S. side, green border with black on surface.	<ul style="list-style-type: none"> dark red/brown lead-based material 75µm lime white ground 180µm 	<ul style="list-style-type: none"> proteinaceous coating 10µm lead pigment has altered to form a dark material which appears to be a mixture of lead dioxide (plattnerite) and lead sulphide
44	Vault, E. bay, E. segment, S. side, green background below Christ's hand, white decorative spot over green.	<ul style="list-style-type: none"> lead white 90µm vivianite 55µm 	<ul style="list-style-type: none"> proteinaceous coating 5µm
45	Vault, E. bay, E. segment, mandorla, S. side, green over red.	<ul style="list-style-type: none"> white layer (calcium carbonate combined with calcium sulphate) 50µm trace red pigment 	<ul style="list-style-type: none"> beeswax coating proteinaceous material is incorporated in wax coating 35µm
46	Vault, E. bay, E. segment, mandorla, N. side, brilliant green of border.	<ul style="list-style-type: none"> pale blue/green copper-based layer 35µm white ground 75µm plaster substrate 300µm 	<ul style="list-style-type: none"> proteinaceous coating 5µm

The table gives the location where each sample was taken, the sample number, and the stratigraphy of the various layers from the top down, with the thickness of each layer in microns (µm).

Notes

1. Park, D. 1983. The wall paintings of the Holy Sepulchre Chapel. In *Medieval Art and Architecture at Winchester Cathedral*. British Archaeological Association Conference Transactions 1980, VI, 38–62.
2. I am indebted to Stephen Rickerby and the students of the Conservation of Wall Painting Course, Courtauld Institute, for their observations during the work in the chapel, and for providing the drawings used in Figures 4 and 6. Previous investigations of aspects of the paintings include: Hluvko, S. 1991. Red pigments in English medieval wall painting; and Howard, H. 1988. Blue pigments in English medieval wall painting. Diploma dissertations. London: Conservation of Wall Painting Department, Courtauld Institute of Art, University of London.
3. This scene, previously described as the *Raising of Lazarus*, was identified by Christoph Tinzl.
4. Lee, M. 1975. Paintings in the Holy Sepulchre Chapel, Winchester. Unpublished M.A. report, University of London.
5. For the role of organic additives in plaster, see Sickels, L. 1981. Organics v synthetics: their use as additives in mortars. In *Mortars, Cements and Grouts Used in the Conservation of Historic Buildings*. Rome: International Centre for the Study of the Preservation and Restoration of Cultural Property, 25–49.
6. Deeply undulating surfaces occur in other Romanesque paintings, such as the scheme of ca. 1130 in St. Gabriel's Chapel, Canterbury Cathedral. See Cather, S., and H. Howard. 1994. Romanesque wall paintings in the apse of St. Gabriel's Chapel, Canterbury Cathedral: their technique, condition and environment reassessed. *Arbeitshefte zur Denkmalpflege in Niedersachsen* (11):143.
7. See Rickerby, S. 1990. Kempley: A technical examination of the Romanesque wall paintings. In *Early Medieval Wall Painting and Painted Sculpture in England*. Ed. S. Cather, et al. Oxford: BAR British Series 219, 249–261; Howard, H. 1992. All Saints' Church, Witley, Surrey: scientific examination of the Romanesque wall paintings. Unpublished report. London: Conservation of Wall Painting Department, Courtauld Institute of Art, University of London; Cather and Howard, op. cit. (note 6).
8. These patches were mapped in the 1980s by the Canterbury Cathedral Wall-painting Workshop.
9. Kupfer, M. 1986. Les fresques romanes de Vicq: Étude technique. *Bulletin Monumental* 144:98–132.
10. Park, op. cit., 40.
11. Mairinger, F., and M. Schreiner. 1986. Deterioration and preservation of Carolingian and medieval wall paintings in the Müstair Convent. Part II: Materials and rendering of the Carolingian wall paintings. In *Case Studies in the Conservation of Stone and Wall Paintings*. Ed. N. S. Brommelle, et al. London: International Institute for the Conservation of Historic and Artistic Works, 195–96.
12. Ultramarine was the mineral blue normally employed in Romanesque wall paintings, though azurite has been identified at Kempley (Rickerby, op. cit., 256) and Mårslet, Denmark (Graebe, H., K. Trampedach, and M. Jensen. 1986. Kalkmalerierne i Mårslet Kirke. *National museets Arbejdsmark* 23:164–82).
13. Matteini, M., and A. Moles. 1994. Mural paintings in Wunstorf-Idensen: Chemical investigations on paintings, materials and techniques. *Arbeitshefte zur Denkmalpflege in Niedersachsen* 11:85–86.
14. Cather and Howard, op. cit., 144–46.
15. Matteini and Moles, op. cit., 85.
16. Cennino Cennini. *Il Libro Dell'Arte: The Craftsman's Handbook*. 1933. Translated by D. V. Thompson. New Haven, 26.
17. The acceleration of the rate of fading over time, due to an increased proportion of white, has been shown experimentally for a lake mixed with white, and for a lake used as a glaze over a white ground. See Johnston-Feller, R., and C. W. Bailie. 1982. An analysis of the optics of paint glazes: fading. In *Science and Technology in the Service of Conservation*. Ed. N. S. Brommelle, et al. London: International Institute for Conservation of Historic and Artistic Works, 180–85.
18. Faye, G. H., P. G. Manning, and E. H. Nickel. 1968. The polarized optical absorption spectra of tourmaline, cordierite, chloritoid and vivianite: ferrous-ferric electronic interaction as a source of pleochroism. *The American Mineralogist* (53): 1174–201.
19. I am grateful to Dr. G. Cressey of the Natural History Museum for carrying out analysis by X-ray diffraction using a Debye-Scherrer camera. The possible ad-

- ditional presence of metavivianite (a polymorph of vivianite) was indicated by this analysis.
20. Richter, E. L. 1988. Seltene pigmente im Mittelalter. *Zeitschrift für Kunsttechnologie und Konservierung* 2 (1):171–77.
 21. J. Darrah. 1987. Personal communication. Victoria & Albert Museum, London.
 22. Mineral deposits are found in England, France, Germany, Italy, Portugal, Serbia, and the Ukraine, as well as in the United States and elsewhere. I am grateful to Mr. Peter Tandy of the Natural History Museum, London for providing this information and for guiding me through the extensive range of samples in the collection. I am also indebted to Dr. Brian Young of the British Archaeological Survey for his enthusiastic interest and informed opinion on the provenance of the mineral.
 23. Watson, T. L. 1918. The color change in vivianite and its effect on the optical properties. *The American Mineralogist* 3 (8):159–61.
 24. P. Tandy. 1994. Personal communication. Natural History Museum, London.
 25. Following initial exposure of the colourless mineral, oxidation of one of the paired ferrous ions may occur at the surface and along crystal cleavages. The resulting intervalency charge transfer between the paired ions (now Fe²⁺ and Fe³⁺) produces a blue color. Cressey, G. 1994. Personal communication. Natural History Museum, London.
 26. Hanzel, D., W. Meisel, D. Hanzel, and P. Gütllich. 1990. Mössbauer effect study of the oxidation of vivianite. *Solid State Communications* 76 (3):307–10.
 27. This information was kindly provided by Mr. David Perry and published by Park, op. cit.
 28. Oakeshott, W. 1981. The paintings of the Holy Sepulchre Chapel. *Winchester Cathedral Record* 50, plate 98a.
 29. Welford, P. 1991. Investigation of the phenomenon of dark flesh areas in English medieval wall painting. Diploma diss. London: Conservation of Wall Painting Department, Courtauld Institute of Art, University of London.

Abstract

It is rare for ancient external paint to survive the English climate, particularly in the original location of the paint. It is vital that evidence of color be documented, and studied current recognition of this need has created opportunities to survey the fabric of important historic buildings for evidence of paint.

Analysis of paint fragments found on the richly sculpted west front of Exeter Cathedral has revealed evidence of a magnificent polychromy on both architecture and sculpture, giving vital information on fourteenth- and fifteenth-century materials and techniques. A similar investigation on the west front of Salisbury Cathedral has just commenced. An initial look at surviving evidence of polychromy enables some comparisons to be made, in addition to other relevant examples.

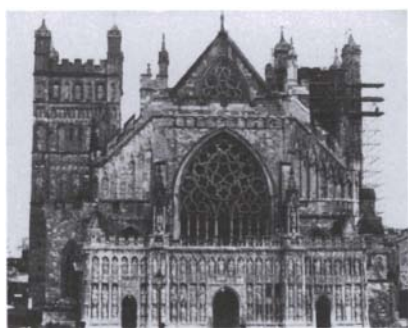


Figure 1. Exeter Cathedral, west front, showing image screen. Photograph courtesy of the Cathedral of St. Peter in Exeter.

The Polychromy of Exeter and Salisbury Cathedrals: A Preliminary Comparison

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Introduction

There has been in recent years an increasing awareness of the historic importance and vital role of color in medieval architecture, as there is at last recognition that our ancient buildings, and not just the artifacts within them, were painted as an integral part of their overall design.

The Reformation in England in the sixteenth century resulted in the destruction or obliteration of much polychromy. Where any evidence of color still exists it is frequently only fragmentary, but those fragments retain much valuable information.

Conservation work on the west-front image screen of Exeter Cathedral carried out from 1979 to 1984 revealed much evidence of a rich polychromy in the form of paint fragments surviving in the most sheltered corners of both architecture and sculpture. Although the study of this polychromy is discussed in detail elsewhere, the establishment of a large archive of paint samples has created an invaluable resource that can be used with other emerging fragmentary evidence (1, 2). As well as providing useful reference material, these samples contain much information not yet explored that future similar projects may yet discover (3).

The work on the Exeter polychromy, while not the first English cathedral to receive such attention, was on an unprecedented scale (4). As conservation work is carried out on more cathedrals and other important buildings in England, investigations into the color become a vital element of the work undertaken. Similar investigations in other European countries have provided a wealth of detailed information, summarized by Rossi-Manaresi and more recently by Brodrick (5, 6). Each cathedral adds its own invaluable evidence to the complex picture of materials, techniques, and workshop practice of medieval times.

With conservation work due to commence on the west front of Salisbury Cathedral in winter 1994, an inspection for polychromy was requested. A preliminary investigation with access to only part of the facade has shown evidence of color. Some analysis has been carried out to date, with further work anticipated in 1995.

Exeter Cathedral west front

The west-front image screen of Exeter Cathedral dates from the fourteenth- and fifteenth-centuries, although much of the crenellated parapet and some portions of the architectural elements, along with six sculptures and the heads of four others, have been replaced over the years (Fig. 1). Most of the fabric is built from Beer stone, a local compact, close-grained limestone.

Much vital information on the materials and techniques of the medieval period are provided in the Exeter Cathedral fabric accounts for the period 1279–1353 (7, 8). Although the fabric accounts are missing for most of the period during which the west front was being constructed and decorated, they provide a wealth of information relating to the polychromed bosses of the high vault which, combined with an examination of the fabric discussed,



Figure 2. Salisbury Cathedral, west front. Photograph courtesy of the Courtauld Institute of Art.



Figure 3. Salisbury Cathedral, north face of north turret, lower register. Evidence of paint was found on the moldings above the figures. Photograph courtesy of Dean and Chapter, Salisbury Cathedral.



Figure 4. Salisbury Cathedral central porch, tympanum. Photograph courtesy of Dean and Chapter, Salisbury Cathedral.

enhances our picture of the working process (9). This, too, can be of immense value for comparative purposes with the west front.

Much of the west front of Salisbury Cathedral (Fig. 2) was restored in the nineteenth century, when most of the empty niches were filled with new sculpture. Only portions of eight sculptures derive from the original scheme of 1245–1260, which may never have been completed. The majority of architectural and all of the ornamental and sculptural stonework on Salisbury's west front is constructed of the local Chilmark stone, a sandy limestone. With much of the stone weathered and covered in lichen, it is not always immediately apparent whether the fabric is original or replacement. Unfortunately, while there is documentation for much of the restoration work, there appears to be none recording the original fabric.

A preliminary inspection for paint on the facade revealed evidence only on the moldings above the lower register figures on the north face of the north turret, the most protected part of the west front (Fig. 3). More evidence of paint may become apparent as cleaning commences on the west front in 1995.

The inspection for paint extended into the sheltered central porch where, again, much of the fabric is from the nineteenth century. On the tympanum, however, the medieval surfaces that have remained are in areas still thickly painted, with ample evidence of a magnificent polychromy (Fig. 4). The only original carving is that of four heads at the apex of the tympanum; they are particularly well protected and retain paint on their hair, beards, and eyes.

An examination of the roof bosses in the west walk of Salisbury cloister, which date from 1263–1270, also reveals evidence of color though here the paint is extensive, with some bosses retaining almost all their color. While their polychromy cannot be seen as part of the same scheme as that of the west front and central porch it serves as valuable additional reference material, as well as an important surviving fact in its own right.

Paint samples were taken from all three locations at Salisbury to analyze the type of pigments and binding media used by the medieval painters. These analyses are still in progress and much remains to be done. Further evidence may yet come to light that will alter current perception of the preliminary results.

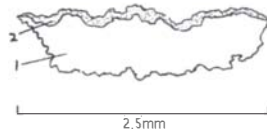
Salisbury polychromy

Although the scarcity of evidence of paint on the west-front facade makes it rather premature to talk of differences or similarities, a preliminary examination of the paint from all three locations immediately reveals a difference in technique (Fig. 5).

Those west-front samples examined thus far show the existence of a thick white ground with a single, colored layer on top (Fig. 5a), while those from the cloister bosses show a thin, translucent white ground with one or two colored layers on top and extensive use of gilding, which may also bear painted decoration (Fig. 5b). By comparison those from the central porch display a more complex structure (Fig. 5c), with some samples exhibiting up to fifteen layers and several repaintings, often resulting in a change of color, with the use of a red earth primer, liberal applications of white lead and a broad range of colors (Plate 21). Presumably the paint was reapplied whenever it started to look shabby; there are three layers of gilding on the beard of one of the carved heads. Samples examined thus far from the cloister bosses show no evidence of repainting.

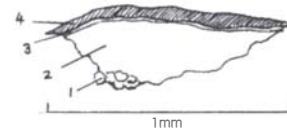
Although more paint may yet be discovered on Salisbury west front, current results indicate several possibilities. If the sculptural scheme was left unfinished, perhaps only isolated, completed areas were painted. Alternatively, the scheme may have been completed, but left largely unpainted due to lack of funds. Weathering and human intervention may have caused loss of most of the

5a. Location : Salisbury west front, north face of north turret.



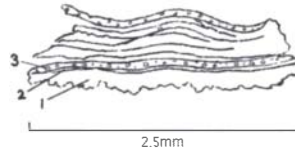
1. White ground
2. Iron-oxide red

5b. Location : Salisbury, cloister boss.



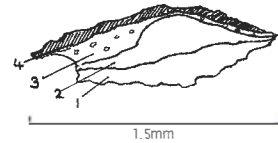
1. White ground
2. Yellow ochre, gold size?
3. Gold leaf
4. Black decoration

5c. Location : Salisbury central porch, tympanum.



- Multi-layered sample, with
1. Red earth primer,
 2. White lead undercoat,
 3. Vermilion top layer and several repaintings of primer, white lead and vermillion.

5d. Location : Exeter west front, drapery of king.



1. Pink primer
2. White lead
3. Vermilion
4. Black cement layer

Figure 5. Paint cross sections: a preliminary view.

paint, but protected corners usually retain odd fragments, as was found on the north return.

At this point in the investigation, the discovery of the existence of paint in just one area on Salisbury west front could be the result of a poor technique. The careful preparation of the stone with appropriate sealant, primer, and ground played a major role in the durability of the paint layers above. The initial examination of the north turret samples at Salisbury suggests that the white ground is of a chalk and gesso type, and not very tough, though it is thick and would have provided a smooth surface for the paint. Its softness suggests a loss of medium, though the lack of evidence so far for paint elsewhere may be due to a poor choice of medium.

Visual analysis, largely through the study of cross sections at this stage, reveals a typical medieval palette, with a liberal use of costly exotic pigments, particularly in the central porch. Pigments here include vermillion, verdigris and copper resinate greens, black (probably lamp black), red and white lead, a dark blue that appears to be indigo, red and yellow ochre, and gold leaf. The cloister pigments include red and yellow iron oxide, black, gold leaf, a cool blue-green and a calcium carbonate white. No lead pigments have yet been identified here. Only two pigments, red and yellow ochre (with a chalky white layer below), have been identified on the west-front facade.

Exeter polychromy

That any paint survives at Exeter, in spite of several major cleaning programs, must be due to a careful selection of superior quality materials (Fig. 5d) with abundant use of durable red and white lead. Most samples are well bound, though migrating salts and some loss of medium cause some paint to delaminate.

A typical sample from Exeter west front has—on top of an invisible sealant—a red earth primer followed by a pale pink primer consisting of iron-oxide red, chalk, white and red lead, all in varying proportions (Plate 22). On top

of this, a lead white undercoat provides a tough resistant layer, often also used to enhance the colored layer above, which may in turn be covered with a glaze color.

Techniques: Salisbury and Exeter

Although the structure of the Exeter west-front samples in no way resembles that of the samples from Salisbury west front, there is a greater similarity to those samples from the central porch, where a similar range of pigments are combined with a complex layer structure. The presence of white lead in the porch at Salisbury will have played some part in the survival of the paint there.

The use of three different techniques, apparent even at this early stage of the Salisbury investigation, with the indication of two different techniques operating on the west front, is in keeping with evidence found on other European cathedrals of a considerable variation in technique existing on large-scale schemes (10, 11).

The richest colors and effects at Salisbury may have been reserved for the main doorway, the grand ceremonial entry into the cathedral (12). If less expensive preparations were used elsewhere, as is suggested by the north turret evidence, this could explain their disappearance. At Exeter, the evidence of a rich repainting around the main entry also suggests the important role played by color in the liturgy of a great church, where the main entry was not considered complete without its polychromy and was renewed more frequently than elsewhere (13).

The medium of weathered exterior paint has naturally deteriorated, making reliable analysis extremely problematic. Both linseed oil and egg tempera appear to be present in the samples from Exeter west front, either as an emulsion or to temper different layers. While no media analysis has yet been carried out on the Salisbury west-front samples, those from the porch appear to be in an egg tempera medium and those from the cloister in linseed oil. At Salisbury, however, the usual problems of media analysis are further complicated by the presence of lichens, algae, bacteria, and also the identification of wax. A protective coating applied in a previous restoration has left a brown-yellow wrinkled skin over much of the stonework, further complicating analysis.

With most surviving paint at Exeter found in deep crevices, much of the detail of the finely carved Beer stone must have been lost, as layers of paint fill corners of crockets, nostrils, or finely carved hair. The skill of the medieval painter was to use his craft not merely to paint the carved form, but to embellish and further enhance it. At times this must have entailed repainting obscured detail by redefining highlights and shadows to carved hair.

Similarly, the moldings around the tympanum and the carved heads at the apex in the central porch at Salisbury must have needed picking out in fresh color, as the corners lost their clarity over the years, with a build-up of paint particularly thick where different planes meet and overlapping of color occurs. Where the stone is sound on the west aisle cloister bosses, the carving remains crisp, as there is no build-up of paint layers to clog up the detail.

The painter did not rely on the play of light alone to give form to the sculptures, but added depth to hollows with shading or highlights to high points where paint rarely survives on an exterior. Traces of black in the inner moldings of the orders around the tympanum at Salisbury show how hollows were further emphasized by the choice of dark colors. Carvings are thrown into relief by the background color from which they emerge. Thus, in the porches at Exeter, the foliage around the doorways, now mostly bare stone, is defined by the thick traces of indigo still surviving in the corners of the background.

The painter would add details to carving—even if they would never be seen by the ordinary viewer—such as the delicate red outline defining the most

sheltered eye on the southernmost carved head in the porch at Salisbury, remarkably similar in style to that found on one of the polychromed heads on the cloister bosses.

No metal leaf was found on the facade at Exeter, although the fabric accounts list the purchase at Christmas 1341 of “gold, silver, and various colors for painting the image of the blessed Peter” high up in the gable of the west front (14). Instead there were several occurrences of orpiment where gold might have been expected, such as on crowns and hats; presumably this was used elsewhere for reasons of economy.

A reference to “the painting of the bishop in the gable,” makes it clear that the final costly colors and foils were applied in situ (15). As for primings and earlier preparations, these may have been carried out in the shelter of the workshop, as was the case with the interior bosses in the crossing, where red lead priming can be seen disappearing into the masonry joints under the medieval mortar (16). However, recent developments have shown that the quire bosses must have been totally painted in situ (17). Both practices, therefore, were possible and were operating at Exeter. Workshop practice at Salisbury is yet to be explored, though the presence of dirt beneath the lowest paint layer on the cloister samples suggests that they were left unpainted for some time.

Conclusion

While it is too soon to draw conclusions about surviving external color at Salisbury, the discovery of its very existence is important, placed in the context of a tradition that was soon to disappear from English ecclesiastical buildings, although it lingered a little longer in a secular context (18). The search for further evidence of polychromy will continue at Salisbury, along with a more detailed study of identified paint traces.

It is hoped that evidence of polychromy from Exeter, and now Salisbury, however fragmentary, can be seen as part of a European Gothic tradition. It would be interesting to see if a more detailed study reveals any differences in style to distinguish English architectural polychromy from that of its European counterparts.

Acknowledgments

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Notes

1. Sinclair, E. 1991. The west front polychromy. In *Medieval Art and Architecture at Exeter Cathedral*. Ed. F. Kelly. British Archaeological Association, 116–33.
2. Sinclair, E. 1992. Exeter Cathedral: Exterior polychromy. In *The Conservator as Art Historian*. Ed. A. Hulbert, et al. London: United Kingdom Institute for Conservation, 7–14.
3. The author, a practicing conservator, carried out this research, with invaluable help and tuition from Drs. Ashok Roy and Raymond White of The National Gallery, Josephine Darrah of the Victoria & Albert Museum, Peter Mactaggart, and Anna Hulbert. However, access to sophisticated analytical equipment and techniques was limited, and most results are based on the study of cross sections and dispersions.
4. Conservation work on Wells Cathedral west front, carried out from 1974–1986, uncovered extensive evidence of polychromy that will be reported on in Sampson, J. *Wells Cathedral: West front archaeology and conservation*. Forthcoming.
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6. Brodrick, A. 1993. Painting techniques of early medieval sculpture. In *Romanesque Stone Sculpture from Medieval England*. 18–27.

7. *The Accounts of the Fabric of Exeter Cathedral, 1279–1353*. 1981. Part I, 1279–1326. Ed. A. Erskine. Devon and Cornwall Record Society, 24.
8. *The Accounts of the Fabric of Exeter Cathedral, 1279–1353*. 1983. Part II, 1328–1353. Ed. A. Erskine. Devon and Cornwall Record Society, 26.
9. Hulbert, A. 1991. An examination of the polychromy of Exeter Cathedral roof bosses, and its documentation. In *Medieval Art and Architecture at Exeter Cathedral*. Ed. F. Kelly. British Archaeological Association, 188–98.
10. Rossi-Manaresi, op. cit.
11. Sampson, J. Personal communication. At Wells, three different techniques were identified by Dr. Roy (National Gallery, London) with the use of either white lead or gypsum (?) as a ground. The niche in which *The Coronation of the Virgin* is situated, above the main west door, retains evidence of the more exotic pigments on a lead white ground.
12. In a search for polychromy during recent work on the west front of Bath Abbey, Jerry Sampson found that, apart from one isolated fragment elsewhere, the only paint was in the west door. This may be the result of a poor technique resulting in almost total disappearance of color, but it suggests again the importance of the main doorway. See Sampson, J. 1992. *Bath Abbey West Front: The History of the Restorations*. Private report. Bath City Council and English Heritage.
13. Rossi-Manaresi, R., and A. Tucci. 1984. The polychromy of the portals of the gothic cathedral of Bourges. *ICOM Committee for Conservation preprints, 7th Triennial Meeting, Copenhagen*. During construction of the west front, the south portal was used as the main entry. Here, twelfth-century carvings, unpainted until incorporated into the south portal in 1225, were then polychromed in situ, forming a temporary main entrance. Bourges Cathedral is contemporary with Salisbury Cathedral.
14. Erskine, 1983. Op. cit., 269.
15. Ibid., 270.
16. Hulbert, op. cit., 192.
17. Hulbert, A. 1994. Personal communication.
18. Sinclair, E. 1990. Appendix: Sampling and analysis of paint traces from the exterior elevations of the front block. In *Exeter Guildhall*. S. R. Blaylock. Exeter: Devon Archaeological Society Proceedings (48):174–6. Research on the exterior of Exeter Guildhall revealed a rich polychromy that included azurite, vermilion, and gilding, with the earliest layers dating from 1593 to 1594.

Abstract

Extensive examination of Andrea Mantegna's *Adoration of the Magi* at the J. Paul Getty Museum reveals Mantegna's unusual technique of painting. Although this painting was generally described as painted in tempera or oil, analysis has revealed the medium to be distemper (animal glue). The rationale for this technique is explained here in terms of aesthetic and environmental constraints of the fifteenth century as well as the art-historical context of the period.

Andrea Mantegna's *Adoration of the Magi*

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Introduction

In 1985 the J. Paul Getty Museum acquired the *Adoration of the Magi* by Andrea Mantegna (1431–1506) (Plate 23). Nothing was known about the painting until the early nineteenth century, when it was thought to have been brought to England by Alexander Baring, first Lord Ashburton (1). It was first shown publicly in London at the Royal Academy in 1871, and then at New Gallery in 1894; but with few other exceptions, the painting was not readily accessible. This might explain why it was sometimes confused with a nineteenth-century copy, now in the Johnson collection in Philadelphia (2). The *Adoration* was shown again in London in 1981 in the exhibition *Splendours of the Gonzaga*, and has since been widely accepted as a late work by Mantegna, dated circa 1495–1505. The composition of this popular subject must have been much admired, for at least seven copies by other artists survive (3).

The horizontal composition with five half-length figures placed tightly around the Christ Child bears resemblance to other works by Mantegna, such as *The Virgin and Child with Saints* in the Galleria Sabauda in Turin and *The Presentation in the Temple* in the Staatliche Museen zu Berlin. Mantegna seems to have been the initiator of this type of composition, which inspired Giovanni Bellini, Cima da Conegliano, and Vincenzo Catena, among others. Remarkable are the descriptive features and the distinctive skin color of each individual figure. Noteworthy is Mantegna's foreshortening of the Christ Child's right leg, which is reminiscent of the *Lamentation* in the Brera in Milan. Most of the execution adheres to Mantegna's original composition, with the exception of the faces of the Virgin and the Christ Child, in which the X-radiograph shows Mantegna's original reworking or pentimenti (Fig. 1).

Analysis of painting technique used in the *Adoration*

In order to properly restore the *Adoration*, extensive research on the unusual technique of this painting was necessary. Although the Getty *Adoration* was generally described as painted in tempera or oil, recent analysis carried out by the Getty Conservation Institute has identified the medium as distemper (animal glue) (4). Pioneering research done by John Mills of the National Gallery in London and other experts in the 1970s drew attention to the fact that this medium was widely used during the Gothic and Renaissance periods (5). Within the next decade more accurate methods of analysis were developed (6). The principal reason for the lack of more information has been the difficulty in analytically distinguishing egg from glue, as both are complex proteins. The analytical results can also be unreliable because infusions of glues from later relinings and consolidants make it difficult to determine whether they are part of the original medium.

Throughout the history of painting, the use of glue as a medium has been quite common, yet very often paintings in this medium are classified as tempera paintings, such as the mummy portraits of the late Fayum period (third century C.E.), which were no longer painted in encaustic, but probably with a glue medium (7). In Germany and particularly in the Netherlands of the fifteenth and sixteenth century, thousands of distemper paintings were pro-



Figure 1. X-radiograph of Andrea Mantegna's *The Adoration of the Magi*. The J. Paul Getty Museum, Malibu.



Figure 2. Dieric Bouts, *The Annunciation*. Distemper on linen, 90 × 74.5 cm. The J. Paul Getty Museum, Malibu (85.PA.24).

duced, including examples by great artists such as Albrecht Dürer and Pieter Brueghel (8). Some of these that have survived relatively untouched show us the beauty and brilliance of this medium. Well-preserved examples of this technique include three paintings by Dieric Bouts: (a) the *Annunciation* in the collection of the J. Paul Getty Museum, Malibu (Fig. 2); (b) the *Resurrection* at the Norton Simon Museum, Pasadena; and (c) the *Deposition* in the National Gallery, London (9). Many of these paintings, however, have either been destroyed or severely damaged and altered. The glue renders the paint film brittle and readily damaged by water; because of the glue's hygroscopic nature, it attracts dust and candle soot. Consequently, most of these paintings suffered the fate of being varnished in order to “liven up” the colors, thus becoming oil or varnish paintings by absorption. Most of them were destroyed because they were so fragile, and less than 100 of the above-mentioned Netherlandish paintings have survived (10).

In Italy, however, Andrea Mantegna was the only artist to make extensive use of this technique. Approximately thirty of his distemper paintings have survived.

Mantegna, with some of his fellow painters north of the Alps, must have been intrigued with the effect of light, or the lack of it, on his paintings. In order to visualize the effect of different media in the same light, we need only look at an illuminated manuscript in the subdued light of a modern showcase to marvel at the glowing colors (11). By contrast, it would be practically impossible to view an oil painting under the same light conditions because of the deep saturation of the pigments and the different refractive index. Mantegna probably faced the same dilemma of wanting to create paintings with incredible detail and luminosity that would not lose their visual power due to lack of light and the distracting reflections caused by a varnished surface. Because we live today in a technically advanced age in which we can regulate the light we need, it is difficult to imagine relying on candles and torches. Yet, until the wide distribution of electricity less than one hundred years ago, light in a closed environment was scarce. Until the Renaissance, many palaces and buildings in Italy had only a few small windows; many of Mantegna's paintings were probably destined to be hung in a private bedroom or chapel in the fortresslike Ducal Palace in Mantua, thus a technique that would not

create surface gloss and could be viewed in subdued light was ideal. Of all the techniques, only fresco and distemper have these characteristics and only distemper, which is more brilliant, gives the artist a limitless time to work (12). Distemper paintings are also light and portable. A letter by Mantegna to Ludovico Gonzaga, Marquis of Mantua, suggested painting portraits on fine linen in this technique, as they can be rolled up on a dowel and easily shipped (13). These advantages and characteristics might explain why Mantegna, the absolute perfectionist, had such a predilection for distemper.

The animal glue for distemper painting was made from either skins or parchment, preferably sheep or goat (14). Glue made out of fish bones was also used; it has been identified in the *Cult of Cybele* by Mantegna at the National Gallery in London (15). The glues were prepared and dried into tablets in the winter to keep them from growing mold. When the glue was needed, it was first soaked in water and then dissolved in a hot water bath.

Historical methods and recipes

A rather succinct description of the practice of this distemper technique is given in the so-called Eraclius manuscript. In recipe XXVI of *De Coloribus et Artibus Romanorum*, the text states (16):

If you wish to paint on linen cloth, and lay gold upon it, prepare it thus: Take parchment, or clippings of parchment, and put them in a jar with water, which must be placed over the fire and made to boil as before directed; then dip a cloth into it, take it out immediately, and stretch it out on a wet panel and let it dry. Then burnish or polish it all over with a glass muller, and stretch it out, fastening it on to a wooden frame with the thread. You may then paint upon it with colours distempered with size, or egg, or gum.

The recipe describes how the cloth was treated to make it less absorbent, so that the colors would not be soaked into the cloth and spread out. Only such a pretreated cloth could be painted on with some detail. It is this same property that is alluded to in Jehan le Begue's 1431 recipe compilation *Experimenta de Coloribus* (17):

In England the painters work with these waters upon closely woven cloths [sindone?], wetted with gum water, made with gum arabic and then dried, and afterwards stretched out on the floor of the soler . . . and the painters . . . paint upon them figures stories and other things. And because these cloths lie stretched out on a flat surface, the coloured waters do not flow or spread in painting upon them . . . the touches of the paint brush made with these waters do not spread, because the gum with which, as already mentioned, the cloth is wetted, prevents their spreading. . . .

Glue gels at room temperature, however, making it difficult to use. The difficulties of keeping the medium in a workable consistency are described in the *De Coloribus Diversis Modis Tractatur in Sequentibus*, written in 1398 by Johannes Alcherius. In a recipe given to Alcherius by the Flemish painter Jacob Coene, instructions are provided for painting and “laying gold on parchment, paper, linen cloth, *sindone* [very fine linen], and on primed wooden panels. The recipe describes the making of glue out of parchment or cutting of fine leather: “Lastly, let the size, or sized water be warm; I say warm, lest it may be conglutinated, . . . when it is cold it will be congealed like jelly . . .” (18).

Alcherius continues, “Moreover when using a paintbrush, the colour may be held in the hand, which by its warmth or heat will not allow it to congeal . . . And in painting with a pen, as well as with a paint brush, it is a good thing to keep the colour over a slow fire of charcoal at such a warmth, that it may not congeal, but may remain liquid” (19).

The recipe stresses the fact that—in contrast to painting on panel—when painting on cloth or Tüchlein, the artist should apply paint in several layers (20):

On cloth and sindone it is more necessary that this colour should be layd on twice, wile tempered with size, before it is put on for the last coat tempered with white of egg. And this is because sindone and cloth, owing to their porosity, are too absorbent, flowing, flexible, and unstable, and therefore soak up the colour, so that there does not remain a good and firm substance of colour upon the cloth or sindone, unless, as useful experience tells us, it is laid on several times.

After the first layer was applied, the surface of the canvas was burnished to receive the second layer and finally a last layer and gilding (21):

Let those things dry which you have drawn and painted, and when they are dry burnish them, that is, polish or smooth them gently with a tooth of a horse or a boar, or with a polished hard stone fitted for this purpose, in order that all the roughness may be softened down, . . . and again paint over and draw upon those same places, with this colour, as before, and afterwards let it dry, and then polish and burnish it as before. Afterwards go over and repaint those places which you did before, with the same mordant or colour, but let this third and last coat of colour be tempered with white of egg. . . .

Sometimes painters tried to prepare the medium in such a way that it retained a workable consistency without being heated. This is why some recipes, including the following two recipes, survive for keeping glue fluid during preparation without heating it: “If you have the time, allow the mordant to get stale, for several days or weeks, for it will be better putrid than fresh” and “if you want to keep it liquid, put in more plain water, and let it stand; and after a few days it will stay liquid without heating. It may smell bad, but it will be very good” (22, 23).

Others describe adding more water and vinegar with honey to the dissolved glue (24). The next day the vinegar is poured off, and clear water is added and heated. When it cools, the glue is stored and eventually becomes liquid. The small amount of vinegar soaked up by the glue also seems to help preserve it. The *De Arte Illuminandi* says, “And know that it is a very good plan to soften parchment or stag’s horn glue with the best vinegar; and when it is softened, and the vinegar poured off, add plain water and melt it, and proceed as has been said” (25). Pigments were mixed with this medium in much the same way as with egg tempera, presumably by first grinding them in water and then adding the medium.

Painted on fine linen, the *Adoration* measures 54.6 cm × 69.2 cm. Judging by the age and type of strainer, it is reasonable to presume that the painting was removed from its original support, which could have been a panel or another strainer as described in the Alcherius manuscript. This would presumably have been carried out in the early nineteenth century for the purpose of mending two horizontal tears. Presumably to repair this damage, a lining canvas was applied to the back with an animal glue or starch paste. In what is preserved of the original canvas, no tack holes or pronounced stretch marks (called “scalloping”) are visible. This might indicate that the canvas was glued to its support, either a panel or a strainer (26). Two paintings by Mantegna with their original supports still exist. One is the *Ecce Homo* at the Musée Jacquemart André in Paris, which is glued to a panel, and the other is the *Presentation* at the Staatliche Museen in Berlin, which has its original strainer (Fig. 3) (27). A slightly raised edge on the top might indicate that the *Adoration* had an engaged frame, such as the Berlin *Presentation*, which has a series of splinters adjacent to the painted frame with the color continuing up along these splinters. An example of an engaged frame survives (Metropolitan Museum of Art, Lehman Collection) that has a remnant of the original canvas by an unknown artist sandwiched between the strainer and the frame (28).



Figure 3. Andrea Mantegna, *The Presentation in the Temple*. Original strainer with panel inserts seen from front, 68.9 × 86.3 cm. Staatliche Museen zu Berlin.

Gold highlighting

The intricate details and extensive gold highlighting of the *Getty Adoration* are laid out over preparatory base colors such as those visible on the borders of the *Ecce Homo*. In the latter, Mantegna probably finished the painting after it was placed into a frame (which no longer exists), as suggested by the fine details painted up to a one-half-inch border all around. The feathered-out colors on two edges of the *Getty Adoration* give an indication of such preparatory colors (Plates 24, 25). The figures themselves are placed against a uniform black background. The halos of St. Joseph, the Virgin, and the Christ Child, painted in shell gold (finely ground gold in gum arabic), are executed with fine, concentric brush marks that gradually become longer and thicker toward the outer rim (Plate 24). The simulated Cufic letters on the Virgin's dress, the coins in Balthazar's cup, the censer and red cap of Melchior, and the earrings and brooch of Balthazar are all highlighted with fine gold lines. This all was done in a technique that is consistent with Alcherius' descriptions.

Concluding observations

The recent Mantegna exhibit at the Royal Academy in London and the Metropolitan Museum in New York provided us with a better understanding of Mantegna's use of distemper and gave us an opportunity to study the varnished and unvarnished paintings next to each other (29).

Many distemper paintings that have been varnished have been considered irreversibly damaged. The recent restoration of the *Adoration* was a successful attempt to improve the aesthetic quality of the painting and reverse the glossy surface to a matte one, a surface that is more consistent with the original technique.

Notes

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2. Elam, C. 1982. *The Splendours of the Gonzaga*. Catalog. London: Victoria & Albert Museum, 122, entry no. 32.
3. Lightbown, R. W. 1986. *Mantegna*. Oxford, Berkeley, and Los Angeles, 446.
4. I am indebted to Dusan Stulik, Michele Derrick, Michael Schilling, and Eric Doehne from the Getty Conservation Institute for their extensive media analysis.
5. Mills, J., and R. White. 1978. *National Gallery Technical Bulletin* (2):71–76.
6. White, R. 1984. The characterization of proteinaceous binders in art objects. *National Gallery Technical Bulletin* (8):5–14.
7. Thompson, D. L. 1982. *Mummy Portraits in the J. Paul Getty Museum*. Malibu, California: The J. Paul Getty Museum, 7.
8. Wolfthal, D. 1989. *The Beginnings of Netherlandish Canvas Painting: 1400–1530*. Cambridge: Cambridge University Press.
9. Leonard, M., F. Preusser, A. Rothe, and M. Schilling. 1988. Dieric Bouts's *Annunciation*. *The Burlington Magazine* (July): 517–522.
10. Wolfthal, op. cit., 6. See also 38–87 in catalogue.
11. Illuminated manuscript artists used media, such as gum arabic, that are similar to watercolors and have very similar optical properties to distemper paint.
12. Mantegna was known to have been an exasperatingly slow painter, as revealed in the correspondence with his benefactor, Ludovico Gonzaga, the Marquis of Mantua.
13. Kristeller, P. 1902. *Andrea Mantegna*. London, 534, doc. 69.
14. Cennini, C. 1960. *The Craftsman's Handbook*. Translated by D. V. Thompson. New York: Dover Publications, 87.
15. White, op. cit., 5–14.
16. Merrifield, M. P. 1849. *Original Treatises on the Arts of Painting*. London: John Murray, 232.
17. *Ibid.*, 89–90.
18. *Ibid.*, 255.
19. *Ibid.*, 262.
20. *Ibid.*
21. *Ibid.*, 262–64.
22. *Ibid.*, 282.
23. *De Arte Illuminandi*. 1933. Translated from the Latin (Naples MS XII.E.27) by D. V. Thompson and G. H. Hamilton. New Haven: Yale University Press, 12–13.
24. Eastlake, C. L. 1960. *Methods and Materials of Painting of the Great Schools and Masters*. Vol. I. New York: Dover Publications, 106–7.
25. *De Arte Illuminandi*, op. cit., 13.
26. Strainers differ from stretchers in that they have no keys. Stretchers became widely used after the eighteenth century.
27. The *Ecce Homo* has the original panel, confirmed by carbon-14 dating, on which the original canvas is glued only by its edges to the back of the panel. The *Presentation* still has its original strainer with two original backing boards inserted into the strainer, as if it were on panel. The *Lamentation* in the Brera, which no longer has its original support, quite probably had one similar to the *Presentation*.
28. Newberry, T., G. Bisacca, and L. Kanter. 1990. *Italian Renaissance Frames*. New York: The Metropolitan Museum of Art, no. 63 (diagram erroneously under no. 64).
29. So far, not a single painting of Mantegna's has been identified as painted in oil, even though there are records of his having ordered walnut oil.

Abstract

In September 1992 the J. Paul Getty Museum acquired Titian's *Venus and Adonis*, which is considered to be one of the few of Titian's autograph paintings of the subject. The inorganic and organic pigments, oil medium of the paint layers, and proteinaceous medium of the ground were examined using various analytical methods. In addition, the authors studied Titian's other, much later version of *Venus and Adonis* located in the National Gallery in Washington, D.C. The comparison revealed distinct differences in style and technique. This multidisciplinary study has shown to be very useful in gaining a better understanding of Titian's working methods. The examination also revealed useful information about various aspects of early Italian oil painting methods in general and helps place the technique of this painting by Titian in context with other paintings of the period.

Technical Examinations of Titian's *Venus and Adonis*: A Note on Early Italian Oil Painting Technique

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Introduction

The story of Venus and Adonis, from Book X of Ovid's *Metamorphoses*, ends with the name of a fragile flower: anemone. As the tale is told, Adonis was a young man of unequalled beauty, who became the lover of Venus (1). Venus was so much in love with him "that she even stayed away from heaven, preferring Adonis to the sky. She used to hold him in her arms, and became his constant companion." She warned her lover not to hunt dangerous animals: "Your youth and beauty, and the charms which make Venus love you, have no effect upon lions or bristling boars, or the eyes and minds of other wild beasts. The fierce boar deals a blow with his fangs, as swift as a lightning flash . . ."

Of course, Adonis did go out hunting. His dogs found a fresh trail, followed it, and roused a wild boar. Adonis tried to kill it, but with the help of its crooked snout the boar dislodged the spear. The boar pursued Adonis and "it sank its teeth deep in his groin, bringing him down, mortally wounded on the yellow sand." Venus, on her way to Cyprus, driving through the air in her chariot, heard her lover's groans. She went down, and with the dying Adonis in her arms, said that an everlasting token of her grief would remain there. His blood dripping to the ground would change into a flower, the anemone. But, just like their love, the enjoyment of this flower is brief "for it is so fragile, its petals so lightly attached, that it quickly falls, shaken from its stem by those same winds that give it its name, anemone."

This story is represented in a series of *poesie* paintings of Classical subjects, by Titian. Such paintings were very popular among wealthy patrons, as their mythological subject matter usually provided an excuse for the depiction of overt sensuality. King Philip II of Spain commissioned a series of poesies from Titian. The *Venus and Adonis* now located in the Prado Museum in Madrid is considered the first of the series to reach its patron in 1554. The last one was *The Rape of Europa* of 1562, now in the Isabella Stewart Gardner Museum in Boston.

Another version of *Venus and Adonis* by Titian recently came into the collection of the J. Paul Getty Museum. This work, showing Venus attempting

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to prevent Adonis from leaving for the hunt, is considered one of the few of Titian's autograph paintings on the subject (Plate 26). In addition to this work and the *Venus and Adonis* in the Prado, another of Titian's paintings by the same name is located at the National Gallery of Art in Washington, D.C. (Plate 27).

Conservation work on the Getty Museum's recent acquisition of *Venus and Adonis* gave the authors the opportunity to perform a technical examination of the painting. It was examined with the use of the following: microscopic methods, including polarized light microscopy (PLM) and scanning electron microscopy (SEM); spectrometric methods, including ultraviolet visible spectroscopy (UV/vis), Fourier transform infrared (FTIR) spectroscopy, fluorescence (FS) spectroscopy, and energy dispersive X-ray fluorescence (EDXRF) spectroscopy; and chromatographic methods, including gas chromatography (GC) and thin-layer chromatography (TLC). X-ray diffraction (XRD) and a number of staining tests and microchemical tests were also used (2). The cooperation between conservators and scientists proved instrumental in gaining a better understanding of Titian's painting technique. This understanding was greatly improved through the cooperation of David Bull of the Washington National Gallery who gave us the opportunity to examine a later version of the *Venus and Adonis* in the gallery's collection using a stereomicroscope. This examination made it possible to compare Titian's execution of the same theme at different stages in his career. Our study was greatly facilitated by Joyce Plesters's pioneering publications on the examination of Titian pieces in the London National Gallery. Her work served as an example for our own research and as a continuing source for comparison, and helped in the interpretation of the analytical results. It also helped the authors place the technique of this particular painting in relation to that of other paintings of the same period, as well as those of Titian's later and earlier periods.

Support

The painting measures 160 × 196.5 cm. The original canvas is a plain weave linen, having 16 threads per centimeter in the warp direction and 18 threads per centimeter in the weft direction. It is made of two strips of canvas, joined by a vertical seam. The right strip measures 101 cm; the left-hand strip is slightly smaller and measures 95.5 cm. The painting has been cut on all sides; it is possible that the left side was cut by 5–9 cm. Plesters has found that the loom width of sixteenth-century Venetian canvases tends to range between 1.06 and 1.10 cm (3).

The painting was first documented in the collection of the Queen Christina of Sweden and then in that of the Duc d'Orleans. The French eighteenth-century engraver Delignon made prints of objects in the duke's collection (4). One of these prints shows the Getty *Venus and Adonis*, in which it can be seen that the original composition may have extended out a bit more on the left side and that it was not originally cut off as close to Venus's foot as it is now. Since the scalloping of the original canvas on the left side is clearly still visible, the losses cannot have been too extensive.

In the Prado version, which measures 186 × 207 cm (as compared to the National Gallery version, which measures 107 × 136 cm), the painting's surface extends a bit further to the left. Comparison of the loss in the Getty painting with corresponding areas in the print and in the Prado version leads to the conclusion that the width of the loss may be accounted for by the difference between the present 101 cm strip and the 106–110 cm width of the average sixteenth-century Venetian loom. At the right of the Getty painting, a relatively large section of the dog's tail, still complete in the Delignon print, is cut off. The amount of the loss is difficult to estimate, but judging from comparison with the print (the Prado version has suffered an even greater loss), it is probably not more than 4–5 cm.

The loss at the upper side, again based on comparison with the Delignon print, and the London and Prado versions, is more extensive. The shaft of the

arrow in Adonis's right hand ends at the edge of the painting. The loss may be estimated at 5–9 cm. On the basis of a comparison with the Delignon print, the original size of the painting may have been 172 × 213 cm.

Ground

The painting has a conventional gesso ground. The ground was chemically identified as calcium sulfate. XRD has shown that it consisted of a dihydrate gypsum. This composition is common for Venetian painting at that time. Gypsum of the dihydrate form occurs when it is used in its natural state. The use of unburned gesso—as opposed to burned gesso, where crystallization water is driven off to an anhydrite form—seems to occur primarily on Venetian paintings. PLM examination, however, has shown that a considerable amount of anhydrite particles were also present. Paintings from Florence and Sienna more often show the presence of anhydrite or hemihydrate grounds (5). Gesso grounds of this type were the same as those used for ground layers on panel paintings, and its use stems from this tradition. In panel paintings, however, several layers of gesso—*gesso grosso* and *gesso sottile*—were applied. The brittleness of the gypsum layers, which form a good first ground on panels, would cause it to crack off too easily from a canvas. Therefore, artists began using thinner gesso layers on canvas; eventually, in the eighteenth century, an oil priming was used instead.

The ground on the Getty Titian is rather thinly applied so that it only fills the spaces between the warps and wefts of the canvas. Cross sections show that it is an unpigmented ground. In some areas, an oily layer containing a few charcoal-black particles was found between the white ground and the first paint layer. It was only later, in the paintings by Tintoretto, for instance, that a colored ground became more common. A passage in the Volpato manuscript refers to Titian's use of white gesso grounds as opposed to the increasing use of colored grounds by other, more modern Venetian painters. Staining of microscopic cross sections with specific reagents gave strong indication that the binding medium of the ground contains proteinaceous material; this was confirmed by the presence of specific FTIR absorption bands. Infrared mapping allowed us to locate the presence of specific bands in the cross sections.

Underdrawing

Infrared reflectography revealed some evidence of underdrawing. The interpretation of the infrared reflectograms is difficult, however, as some features that showed up as broad, dark lines in the reflectogram could be carbon black used in the paint, rather than the underdrawing. It is not immediately obvious, for instance, whether the dog's curled tail in the original underdrawing was intended to be straight. The broad, dark form in the reflectogram may represent a dark, carbon-black pigment in the painted tail, which was actually intended to be curled in the underdrawing. The reflectogram shows sketchy lines in the trees in the background. The sleeping Cupid seems also to have been rapidly sketched before painting. In all, no significant deviations from the preparatory drawing appear to have been made.

Paint layers: the medium

Staining of cross sections indicated that the actual painting was executed in an oil medium. This was confirmed by the presence of characteristic absorption bands in the FTIR spectrum (Fig. 1). Three samples were selected for examination with gas chromatography. One sample consisted mainly of paint for the golden vase in the painting's lower left corner. The other samples contained blue particles for the sky. Contemporary sources often indicate the use of walnut oil, which was generally considered to yellow less with age, for the making of blue paints. Earlier studies of Titian's paintings have revealed that the artist used both types of oil on different occasions. Chromatography showed an azelaic:palmitic acid ratio in all three different samples, indicating

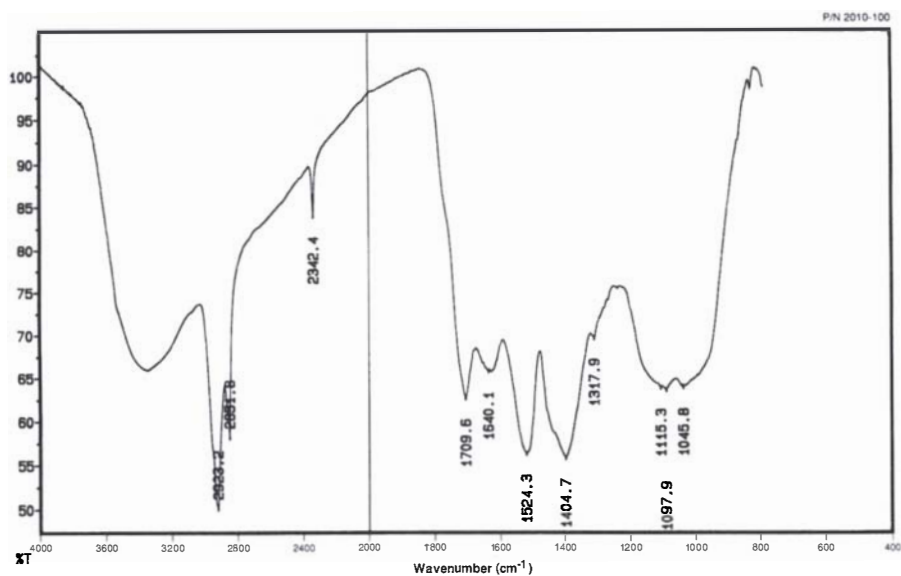


Figure 1. FTIR spectrum of paint sample (no. 17) taken from blue of the sky area. Hydrocarbon stretch bands at 2923 cm^{-1} and 2851 cm^{-1} , as well as the hydrocarbon bend at 1404 cm^{-1} , indicate the presence of an oil medium. The band at 2342 cm^{-1} is characteristic for natural ultramarine.

the use of a drying oil. The palmitic:stearic acids ratios of the samples suggest that the sky was executed in walnut oil or in a mixture of walnut and linseed oils in contrast to other areas of the painting, in which the faster drying, but more yellowing, linseed oil was used.

Painting

The thinness and relatively simple structure of the paint layers are in accordance with what seems to have been Titian's practice around the 1550s. Examination of the cross sections shows that most of the paint was fairly directly and thinly applied, as opposed to the technique he used in his later paintings. In the foreword to Marco Boschini's *Ricche Minere della Pittura Veneziana* (1664), an authoritative and contemporary description is given by Palma Giovane of the manner in which Titian gave form to the paintings he made after the 1550s (6):

He used to sketch in his pictures with a great mass of colours, which served as a base for the compositions he then had to construct. [The compositions were] formed with bold strokes made with brushes laden with colours, sometimes with a pure red earth, which he used for a middle tone, and at other times of white lead; and with the same brush tinted with red, black and yellow he formed an accent; and thus he made the promise of a figure appear in four strokes. . . . Having constructed these precious foundations he used to turn his pictures to the wall and leave them without looking at them, sometimes for several months. When he wanted to apply his brush again . . . he would treat his picture like a good surgeon would his patient, reducing if necessary some swelling or excess of flesh, straightening an arm if the bone structure was not exactly right. . . . After he had done this, while the picture was drying, he would turn his hand to another and work on it the same way. Thus he gradually covered those quintessential forms with living flesh, bringing them by many stages to a state in which they lacked only the breath of life. . . . In the last stages he painted more with his fingers than with his brushes.

This process could involve not just two or three weeks but, with several steps and with long interruptions, could continue for months, even years, resulting in a painting with several paint layers.

The process, as described by Palma Giovane, is distinctly different from the earlier manner in which Titian painted. This difference was already noticed by Vasari in 1566:

For the early works are executed with a certain finesse and an incredible diligence, so that they can be seen from close as well as from a distance while these last pictures are executed with broad and bold strokes and smudges, so that from nearby nothing can be seen whereas from a distance they seem perfect.

In the case of the *Venus and Adonis* at the Getty, the earlier technique was used. The paint layers are few and relatively thinly applied. Where visible in infrared reflectography, the underdrawing seems to have been closely followed. No significant changes from the carefully planned composition have been made. Some later additions seem to have been made, however, in areas such as Adonis's arms and Venus's legs and back. Some areas in the landscape also appear to be built up with several paint layers. The pigments seem to be thoroughly ground directly into the binding medium. This contrasts strongly with the pigments in the National Gallery's *Venus and Adonis*. Observed under a stereomicroscope, many lumps of pigment are visible, suggesting that in making the paint, the pigments were not really ground into, but simply stirred into the oil. Some differences can be noted between the version in the Getty and the one in the Prado. Judging from the development as described by the two contemporary comments, the Getty painting is more loosely executed than the Prado version, and must have been made at a later date, perhaps around 1560. The National Gallery version can definitely be considered to have been painted after the Getty and Prado versions.

Paint layers: the pigments

Yellow pigments. The highlights of Adonis's belt were executed in a bright yellow with occasional small orange-red dots placed on the highlights. When examined with PLM, samples taken from the area showed that the yellow consisted of highly birefringent mica-like particles ($n > 1.66$). The yellow pigment had all the optical characteristics of orpiment, including a laminated form and a waxy luster of the fairly large crystalline particles. The identification of orpiment was confirmed by finding larger amounts of arsenic in the sample. A small microchemical test showed that the sample also contained sulfides.

The red dots on Adonis's belt and the orange-red of Adonis's shoe were also executed in an arsenic-containing pigment realgar. These pigments were identified by the usual means of microscopic and microchemical analysis. In addition, the findings were confirmed by XRD and XRF (Fig. 2).

The use of orpiment and realgar in European easel paintings is comparatively rare, but it is not unusual to find them in Venetian painting; the use of orpiment occurred more often in manuscript illuminations. This lack of popularity may be due to the fact that both pigments are highly poisonous, and good alternatives, such as lead-tin yellow or yellow lakes for orpiment or vermilion for realgar, were readily available. Because of their sulfidic nature, both orpiment and realgar are not very compatible with many other pigments. The Theophilus manuscript even states that orpiment cannot be mixed with any other color because it would destroy them. While realgar was sometimes used to prevent putrefaction of binding media by bacteria, fungi, and microorganisms, historical recipes describing the use of realgar as an actual pigment are extremely rare (7).

Considering their drawbacks, it is surprising to see how frequently these pigments were used in sixteenth-century Venetian painting. They have been identified in several paintings by Titian and Giorgione and in many paintings by Tintoretto and Bassano. The reasons for this preference are not immediately evident. Both mineral substances could not be found in the immediate vicinity and had to be imported. They are conspicuously absent in paintings made in the area around Naples where the minerals actually do occur in the fumaroles near Mount Vesuvius. Their frequent use in sixteenth-century Venice may relate to the increasing use of oil as the paint medium. The pigment

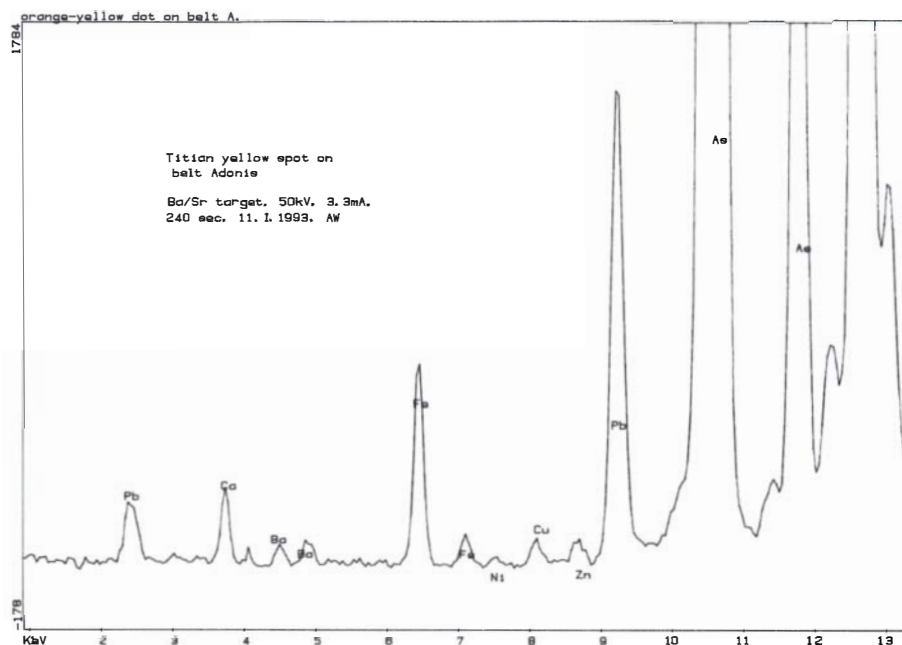


Figure 2. XRF spectrum of yellow area on belt of Adonis. High peaks for arsenic and sulphur suggest the presence of orpiment.

particles, being enclosed in the oily medium, would no longer be incompatible with other pigments, as they were in the previously used tempera techniques. The radiant brilliance of their color in this new medium may have contributed to their popularity.

Ochres were used to paint the landscape, the brownish color of the dogs, and the golden vase near Venus's seat. Yellow ochres (hydrrous iron oxides) were identified under the microscope by their optical properties and by the presence of high peaks for iron in the XRF spectrum.

Blue pigments. The major blue pigment used on this painting was natural ultramarine (Fig. 1). Samples taken from the deep blue of the mountain range appear under the microscope as pale blue, splintery particles with a low refractive index ($n < 1.66$). In the cross section, one can see a single layer of densely packed blue particles.

XRF of several blue areas showed high peaks for cobalt, potassium, and arsenic, strongly suggesting the presence of smalt, an artificial pigment made from potassium-rich glass deeply pigmented with cobalt oxide and ground to a powder. Gettens and Stout suggest that the earliest occurrence of cobalt-colored glass in Europe may have been in the early fifteenth-century Venetian glass industry (8). As the colorant for the glass, a substance called *zaffran* is mentioned. A recipe in a fifteenth-century treatise already mentions the preparation of smalt as a *smalto cilestro* (9).

The source of the smalt in the Getty painting may have been Saxony or Bohemia, where sixteenth-century glassmakers used the locally mined cobaltite (CoAsS) and smaltite (CoAs_2) minerals, which contain large amounts of arsenic, to make smalt. The high peaks of arsenic measured by XRF, in combination with those of cobalt, seem to indicate that cobaltite or smaltite minerals were the source for the blue pigment. It is unclear whether the *zaffran*, or *zaffer* of Italian descriptions, has the same composition as the northern European cobaltite. In other areas of the painting's sky, the original ultramarine was scumbled over with a pale, milky blue. Examination of cross sections of those areas shows that the pale blue consists of a layer of almost completely discolored glassy particles.

Red pigments. Vermilion appears in Adonis's red sleeve. Its presence was established by discovering high mercury peaks with XRF and confirmed by

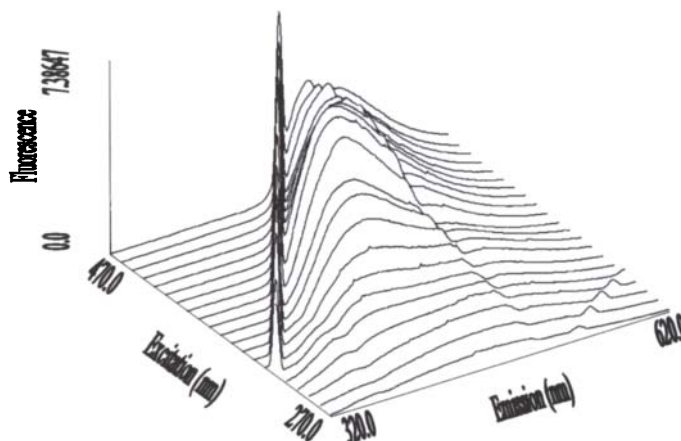


Figure 3. Fluorescence spectrum of red lake pigment on shirt of Adonis. Quantum yields at λ_{em} 445 nm to λ_{ex} 397 nm and λ_{em} 433 nm to λ_{ex} 355 nm indicate presence of a cochineal dyestuff.

microchemical tests and PLM of a sample taken from the area. The other reds in Adonis's tunic and the clothing draped over Venus's seat were of an organic nature. In a sample taken from the seat, an organic colorant was found that also showed the presence of a few textile fibers. This led us to believe that the red lake may very well have been a so-called *lacca de cimatura de grana*. These cimatura lakes were made by an early recycling process. The dyestuffs were precipitated into a pigment lake extracted from red textile clippings or shearings (*cimature*) from a tailor's workshop. The making of such lakes was a fairly common practice, and its description can be found in numerous fifteenth- and fourteenth-century recipe texts (10). The procedure could be performed with most of the available red textiles. The dyestuffs most likely to be found in these lakes are anthraquinone-type dye, such as kermes, cochineal, lac dye, and madder. The analyses by FS and TLC showed the presence of more than one organic colorant; the red appeared to be a mixture. A sample taken from Adonis's garment showed a good match with a library scan of the cochineal standard (Fig. 3). The results were confirmed by chromatography, which also indicated the presence of purpurin, a colorant present in madder type dyestuffs. No spot for alizarin, the major coloring component of common madder (*Rubia tinctorum*), could be found. Several possible conclusions are indicated: (a) wild madder (*Rubia peregrina*) was used, (b) a specific technique was used for the dyeing of the original textile, or (c) the alizarin was not fully extracted in the cimatura process. This finding supports the suggestion that the lake was a cimatura de grana-lake, and the painters who extracted the dyestuffs from textile shearings had no control over the actual dyestuff composition. Since they are similar in color, and not readily distinguishable, any madder-dyed textiles could easily have been included in a larger batch cochineal-dyed clippings.

Lake pigments are known to dry poorly. It was common practice, therefore, to add ground glass to lakes. Sixteenth-century glass was typically very rich in lead; the lead in the glass would act as a siccative, thus promoting the drying of the paint. An interesting passage in the Paduan manuscript describes the process: "To make lake indigo and lamp-black, dry quickly. Grind them with oil, then take glass ground to a very fine powder, and incorporate with the colors by grinding them together again; and thus, in the space of 24 hours, they will dry" (11).

Examination of a microsample of the red lake of Adonis's shirt did, indeed, show the presence of small glass particles. The purplish red of Venus's seat, on the other hand, was made of a mixture of an organic red lake and smalt (Fig. 4). In this case, the smalt had a double function. It gave the carmine lake a more purple color and at the same time acted as a siccative.

White pigments. The white pigment found on the painting was lead white. XRF revealed the presence of lead in the sky and in the flesh tints. Polarized

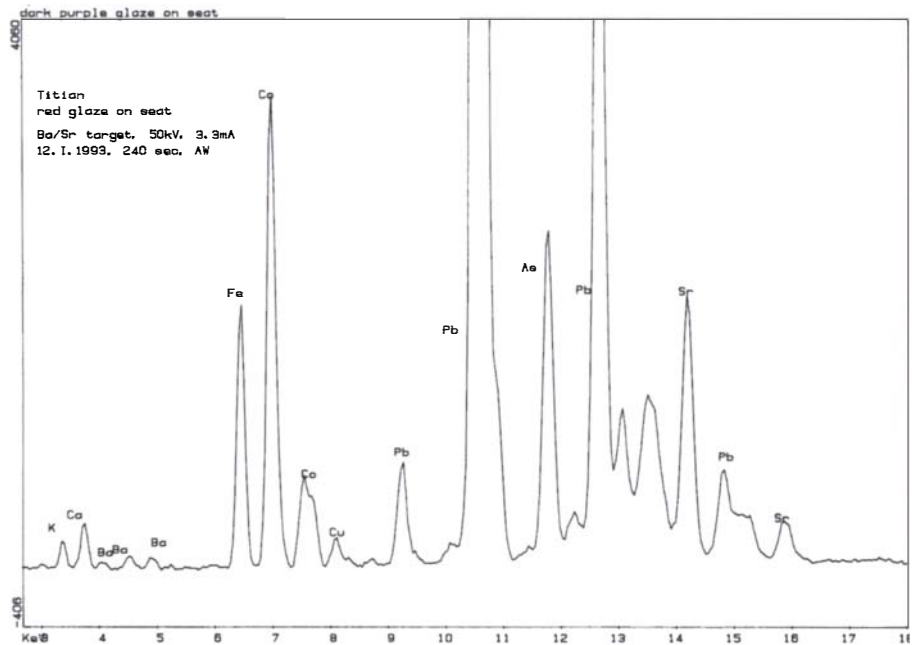


Figure 4. XRF spectrum of purple area on seat of Venus. High peaks for cobalt and arsenic suggest the presence of smalt.



Figure 5. X-radiograph of Venus and Adonis, showing Titian's use of lead-white-based highlights.

light microscopy of pigment samples taken from those areas showed them to contain birefringent particles with a high refractive index ($n > 1.66$) that matched lead-white laboratory standard. This conclusion was confirmed by staining cross sections with Lugol stain. X-radiographs of the painting show how Titian used the lead white, particularly to enhance the contrasts in his composition. It helped to make Adonis's silhouette stand out against lighter areas in the sky, and emphasized the reddish blush on the face of Venus against the bright crimson shirt of Adonis (Fig. 5).

A sample taken from the sky area showed that there was not very much pigment present. The sky appeared to be executed in thin glazes over an anhydrite gesso ground, with the white of the ground showing through. The finding of the lathlike anhydrite particles came as a surprise since anhydrite is generally considered to have been used in more southern areas of Italy. In the Venice region, the dihydrate form was usual. We do not yet have a satisfactory explanation for this. In samples taken from the sky area, a relatively large amount of splintery, isotropic particles with low refractive index ($n < 1.66$) and concoidal fracture could be found. These particles were identified again as ground glass that was added by the painter to promote the drying of the oil.

Green pigments. The greens of the meadow area and the leaves of the trees were executed in verdigris and copper resinate. There are two predominant forms of verdigris: blue basic copper acetate and neutral, recrystallized copper acetate. The latter may be produced by a solution of the former in strong vinegar. Both forms could be used in painting, simply by grinding the pigment in oil. Kühn has found that oil paints made of both copper acetates show a brownish discoloration at the surface after artificial aging, but below the surface, the strong green color might remain well preserved (12).

We observed the same phenomenon in samples taken from the Getty painting. At the time of the painting's manufacture, the green colors made with the verdigris must have looked distinctly different from the way they look now. They must have been much more intense and bluer. In the case of verdigris-oil paints, the paints do not always just consist of particles dispersed in a binding medium. Sometimes the copper acetate may partially dissolve in the medium, forming not only physical mixtures, but also new chemical compositions, like copper oleates, copper resinates, and even copper proteinates.

This property was deliberately used in the making of copper resins. These are complex compositions of copper salts with various resinous acids, such as abietic and succinic acids, achieved by heating verdigris with Venetian turpentine or pine resins. The resulting substance shows no particulate matter, and a strong, bright green color. Copper resinate became the pigment of choice whenever bright green glazes were desired. An early account for the deliberate making of such a compound can be found in a fifteenth-century manuscript in the Biblioteca Casanatense (13). Unfortunately, the copper resins show the same tendency to discolor, giving the meadow and the trees in the background of the Getty Titian their present brown color in place of the originally deep green color. In various areas on the painting, however, the copper resinate has retained some of its original color. In particular, the green leaves of grass near Adonis's foot stand out because of their bright, strong color. Examination of a cross section taken from that area showed that the copper resinate was not laid over the underpaint but rather mixed with lead white. This mixture may possibly have helped in preserving much of its original color. The green of the trees in the background was produced with copper resinate.

The green that was used to paint the meadow near the vase at the lower-left corner consisted of a mixture of copper resinate and yellow ochre. The cross section showed that there were only two different paint layers on the gesso ground: one layer of yellow ochre, possibly applied in two coatings, and an upper layer of copper resinate. The leaves of the plants appear to be highlighted with white, and glazed with copper resinate.

No other green pigments could be identified. This finding tallies with the use of greens in Titian's later *Tarquin and Lucrezia* (14). We were surprised that malachite, found in Titian's almost contemporary *Bacchus and Ariadne* or in Tintoretto's paintings in the National Gallery, could not be detected in the samples we took from the Getty painting (15, 16).

Conclusion

Our examinations show that the execution of the J. Paul Getty Museum's *Venus and Adonis* represents a stage between the Prado version and the National Gallery version. It stands technically in the middle between two extremes in Titian's stylistic development. The earliest stage is the Prado version in which an already conceived image is carefully designed and then executed and filled in accordingly. In Titian's later style, however, the painting grows out of an interaction between matter and concept. As every touch of the brush has its impact on all previous touches, there is a shift in the appearance of the final painting. Rather than resulting from a fixed plan, this way of creating a painting with the total problem of the picture in mind, is apt to be a continually developing and self-revising one.

The Getty piece already represents a concept of painting in which form does not merely follow function, but rather grows out of a continuous interaction between the demands of the material and the artistic idea: "Obwohl das Werk erst im Vollzug des Schaffens wirklich wird und so in seiner Wirklichkeit von diesem abhängt, wird das Wesen des Schaffens vom Wesen des Werkes bestimmt" (17).

Notes

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Abstract

The *St. Anne Altarpiece* (National Gallery of Art, Washington, Widener Collection) is the largest work attributed to the Bruges artist Gerard David (ca. 1460–1523). Several panels of the altarpiece were examined to identify the materials and methods used. The results show that the center panel was painted using a different technique from that for the side and predella panels. There are distinct groupings of underdrawings among the panels. The main panel was laid out more specifically at the underdrawing stage, with three separate drawing campaigns and a correction on top of a paint layer. In the center panel only, all the major forms were laid out in the first paint stage with a lighter value of the final paint color, with multiple layers of progressively more saturated paint built up to create the final appearance. In contrast, the predella and side panels were painted directly, using fewer layers of paint. The program of painting would have allowed for workshop participation, especially in the main panel.

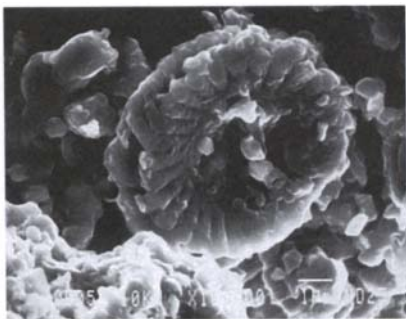


Figure 1. Secondary electron image of the chalk ground of the center panel of Gerard David and Workshop's *St. Anne Altarpiece*, ca. 1506. The coccolith is typical of those found in northern European deposits.

Gerard David's *St. Anne Altarpiece*: Evidence for Workshop Participation

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USA

Introduction

Gerard David (ca. 1460–1523) is known to have been a member of the painters' guild in Bruges by January 1484. It is generally accepted that he operated a workshop, evidenced by the use of pricked drawings and his documented dispute with Ambrosius Benson over the alleged theft of such drawings (1, 2). The recent restoration of the *St. Anne Altarpiece* provided an opportunity for its reexamination and technical analysis (3). This paper addresses the evidence for workshop participation in the altarpiece. The full results of the technical investigation will be published in the future.

The altarpiece

The *St. Anne Altarpiece* depicts St. Anne with the Virgin and Child flanked by St. Nicholas (left) and St. Anthony of Padua (right) (Plate 28). John Hand has described the altarpiece (4). Six predella panels are accepted as part of the original altarpiece; the three panels at the National Gallery of Scotland illustrate three miracles from the life of St. Nicholas, while the three panels at the Toledo Museum of Art show three miracles from the life of St. Anthony. Another panel, *Lamentation of Christ at the Foot of the Cross* (The Art Institute of Chicago, Mr. and Mrs. Martin A. Ryerson Collection), is possibly part of this altarpiece. According to dendrochronological data, David painted the altarpiece around 1506, but the stylistic evidence for dating is less precise (5).

The stiffness and lack of expression of the figures in certain altarpiece panels, especially the central panel and the St. Anthony predella panels, have led to doubts regarding the attribution to David. Workshop participation in the *St. Anne Altarpiece* was proposed as early as 1905 (6). Marlier suggested the participation of Ambrosius Benson in the altarpiece (7). Scillia has attributed the central panel and the St. Anthony predella panels to an assistant (8). Recently, it has been suggested that the entire altarpiece is by a follower of David (9).

The support

The two side panels of the altarpiece, which have been reduced in height, now measure 214 × 76 cm. If the semicircular upper profile is recreated based on the truncated arcs still visible at the upper extremity of each panel, the original height of these panels can be estimated at 236 cm. By comparison to contemporary Italianate altarpieces, the central panel can be assumed to have been even greater in height. The predella panels are 56 cm high. The altarpiece is the largest work in David's oeuvre and one of the largest surviving from the period (10). The scale alone suggests that David would have had assistance in this production. The patron for such a sumptuous and extravagant commission is not yet known.

The central panel is assembled from four boards, each side panel from three. From the relative widths of the central and side panels, it is clear that this was a fixed, not a closing, altarpiece. The oak panels were prepared in the traditional manner with coatings of chalk in glue. Coccoliths in the chalk ground prove a natural, and Northern, source (Fig. 1) (11).

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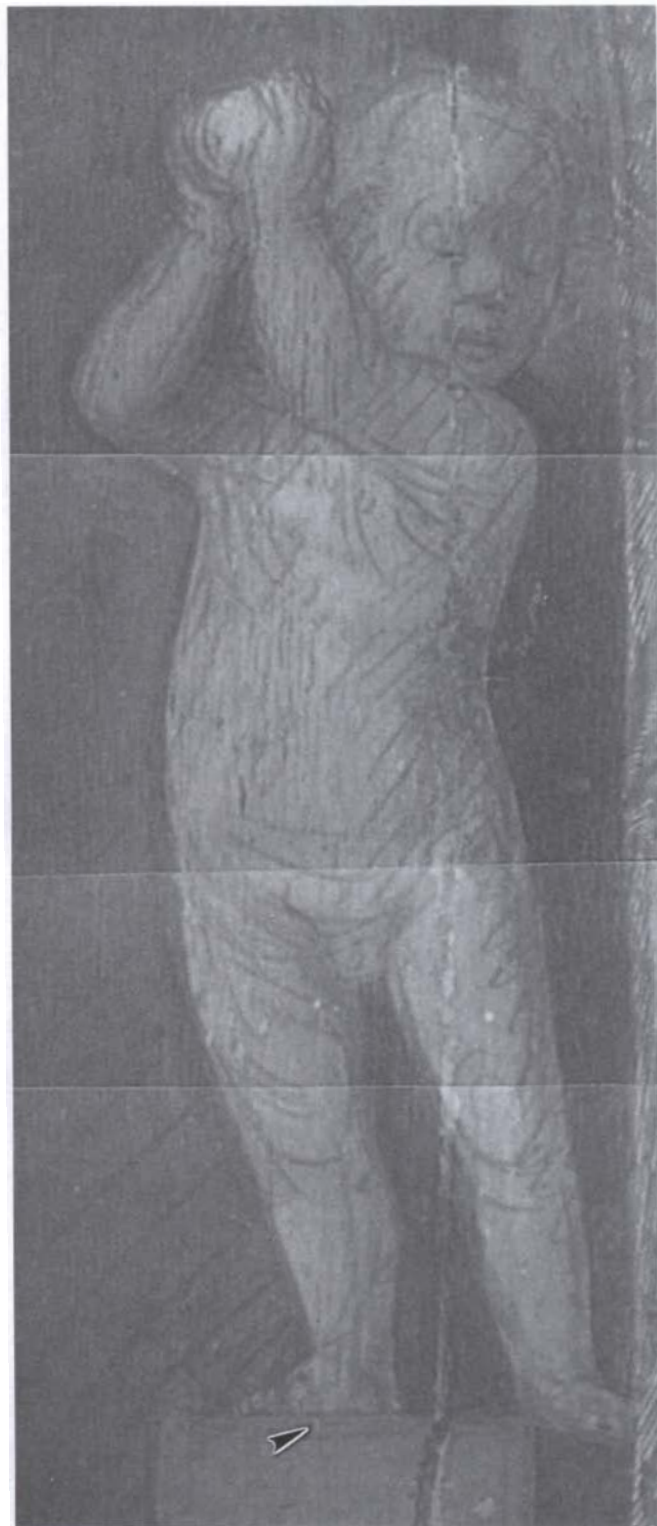


Figure 2. Infrared reflectogram assembly of the cherub standing on the throne (left side, area of reflectogram: 23 × 10 cm). Type I drawing is visible, characterized by an even, relatively narrow width. Reflectograph by M. Faries.

The underdrawing

Infrared reflectography reveals distinct campaigns of underdrawing that can be described in four groups (12). Type I is characterized by a narrow, even line that skips over the surface of the ground. It is the first drawing stage in all three of the main panels and the St. Nicholas predella panels. There is only a small area of type I drawing in one of the St. Anthony predella panels. The drawing made using this material is summary. An example of this drawing type in the cherub on the throne is illustrated in Figure 2. This underdrawing



Figure 3. Infrared reflectogram assembly of the Virgin's head (area of reflectogram: 23 × 17 cm). Type II underdrawing characterized by variable density and line width. Reflectograph by M. Faries.

can be seen in the cross section illustrated in Plate 29a, obtained from the location marked in Figure 3. The underdrawing layer is only a few microns thick.

Type II underdrawing is characterized by variable line width and intensity. These properties, together with the distinctly dropletlike forms visible in some places, suggest type II lines were produced using a liquid. Type II lines are found in the figural group of the center panel, where they describe the forms more firmly. Figure 3 shows the infrared reflectogram of St. Anne's head. Here sketchy type I lines have been overdrawn with the type II underdrawing. Nearly all the underdrawing in the St. Anthony predella panels is executed with a liquid type II drawing material that lays out the composition concisely. In the central figural group of the main panel, however, the line is often rigid and repetitive as, for example, in the shading to the right of the Christ Child.

In addition to these kinds of underdrawing there is a third form, type III, that can be seen with the naked eye in St. Anne's red robe (Fig. 4). These lines are characterized by their bold appearance with handling qualities more similar to that of a paint than of an ink. A cross section shows type III was laid down thickly, and then covered with a translucent layer (Plate 29b). Type III has only been found in St. Anne's red drapery and no other place in either the side or predella panels. A fourth type of marking of form is evident in the reflectogram of the Virgin's sleeve (Fig. 5). Here, a dark irregular line lies over the first layers of paint (Plate 29c). The subsequent layer of paint follows the line denoted by this "correction" layer. Optical microscopy showed the pigment here is charcoal (13). Two panels, *The Miracle of the Purse* and *The*



Figure 4. Infrared reflectogram assembly of part of *St. Anne's red drapery* (area of reflectogram: 24 × 21 cm). Type III underdrawing, which is characterized by its painterly quality, is illustrated. Reflectograph by M. Fairies.

Miracle of the Dead Child, have wandering marks that recollect the appearance of the correction in the Virgin's sleeve. The dotted quality of these lines has led researchers to interpret them as having been produced by pouncing. However, microscopical examination of the paint surface showed that in these locations, the black paint protrudes through the uppermost white layers, giving an impression of a series of dots. These spotty "correction" lines in the predella panels were not followed in the final paint layers, as they were in the center panel.

The looseness and lack of formality of the underdrawing in the two side panels and the predella panels, coupled with the fact that there are many repositionings from the underdrawn to the paint stage, suggests that someone with the authority to interpret the sketch and deviate from it, most likely the master himself, was working on the side panels and the predella panels. The careful additional delineation of outlines in the *St. Anne* suggests that someone who was less intuitive was to work on this panel. The "correction" mark in the Virgin's sleeve, which is followed in the final paint layer, also suggests a second hand in this process. The "correction" marks in the predellas, which are ignored in the final paint stage, suggest the finishing touches were completed by someone who could and did act independently. Participation of workshop members at the underdrawing stage has been noted. For example, Fairies found at least three hands in the underdrawing in the *Crucifixion* triptych in the Rijksmuseum Het Catherijnenconvent in Utrecht (14). The master, Jan van Scorel, drew only in the exterior wings; the drawing in the interior wings and the central panel was executed by two anonymous assistants.



Figure 5. Infrared reflectogram assembly of the Virgin's sleeve, showing the "correction" layer which appears as dotted lines (area of reflectogram: 24 × 21 cm). Reflectograph by M. Faries.

The paint layers

The preparatory layers. Staining the cross sections shows that the chalk ground in the main panels was not coated with a layer of glue before application of the underdrawing. In some of the cross sections, however, there is a dusting of red and black particles in an oleaginous layer; these particles are especially visible under the green cloth of honor behind St. Anne and the Virgin. Scattered particles such as this are rarely noted in painting cross sections; however, Coremans, et al. and later Brinkman, et al. found a similar layer in the Ghent altarpiece (15, 16). There is a clearer indication of the use of a sealing layer over the underdrawing in St. Anne's red drapery. Here the hatching lines, which are visible to the naked eye, have a translucent layer over them, separating the red paint from the drawing lines.

The X-radiographs of all six predella panels have clear indications for an overall, randomly brushed underlayer which must contain lead white to register in the X-radiograph. The few samples from the predella panels show

there is a lead-white underpaint or imprimatura. X-radiographs of the central panel show a similar vigorous, striated, and randomly applied layer in some areas.

The relationship between the underdrawing and the final image. In the main and predella panels, the layers of paint follow the outlines of the underdrawing in a general fashion. There are many major and minor departures from the underdrawn outlines, however, and additional elements have been added to the composition in the paint stage without any redrawing. There are numerous examples in the predella panels. For example, in *St. Nicholas Slips a Purse through the Window of an Impoverished Nobleman*, the hand and purse were painted slightly lower than they are drawn, and a shoe and stocking that were not included in the underdrawing appear. The praying hands of the foremost boy in *St. Nicholas Restores Three Dismembered Children to Life* were lowered in the paint stage and St. Nicholas's crosier was raised in the same scene.

In the side panels, St. Anthony's foreground foot is drawn in a lower position than it was painted. The elaborate gold crosier that St. Nicholas grasps is changed from the drawn to the painted version. These changes were made at the initial stage of painting without any redrawing.

In the central panel, there are fewer changes from the underdrawing to the final image, however, the Virgin's head was painted higher than it was drawn. The X-radiograph shows this change was made after the first layer of St. Anne's wimple had been laid down, after which the head was painted in its new position, without any detectable redrawing.

The pigments and layer structure. The painting technique of the center panel of the altarpiece is similar to that found in the Ghent altarpiece (17). There is evidence for an oil-based sealing layer toned with red and black pigments over the underdrawing and under the paint. The paint structure is multilayered and the colors are worked from light to dark. The cross sections show that each large area of color was blocked in using a light tone of the final color. For example, the Virgin's mantle is underpainted in pale blue (Plate 29d); a blue-green layer blocked in the whole area of the cloth of honor (Plate 29e); and the throne, on which statues of *putti* stand, is underpainted with a lighter gray (Plate 29a) (18). Type III underdrawing provides the mid-tone in St. Anne's drapery, which was painted using two layers of vermilion and red lake covered by multiple layers of a transparent red glaze (Plate 29b).

The paint layer structure in the side panels is not the same as in the center; the build-up of color and form is quite different. St. Anthony's robe has only a single violet-gray layer (Plate 29f). St. Nicholas's chasuble was painted by laying in a yellow ochre base, on which shadows were created with a thick dark layer of black pigment mixed with vermilion. Whereas in the center panel the layers of paint are always tonally related (e.g., red covering red), in *St. Nicholas* yellow paint is used as a base for red and green in the saint's vestments. In the red embroidered chasuble, the cut velvet was painted with a layer of vermilion mixed with red lake. Red glazes were applied to depict the texture.

The technique of *Lamentation at the Foot of the Cross*, as described by Butler, is similar to the technique employed on the predella panels in the use of an imprimatura containing lead white and in the relatively simple layer structure (19). Certain similarities to David's *The Virgin and Child with Saints and a Donor* are seen in the paint structure (20).

Summary

The central figural group of the center panel was produced using a different technique from the rest of the altarpiece. Its structure is similar to those found in earlier fifteenth-century paintings, such as in the Ghent altarpiece (21). This method of working—sealing the underdrawing, laying in light tones,

followed by modeling layers and glazes, with the addition of new drawing as guidelines—would have lent itself to the participation of the workshop. The repositioning of the Virgin's head during the painting process could indicate the continued involvement of the master. Painting with modifications and corrections from the underdrawing, and modeling of tone using very few layers of paint, as is seen in the side panels, requires self-assurance and authority; it would be harder to use assistants in the production of a painting when this was the method of working. Workshop participation in the center panel rather than the side and predella panels is not usually expected, although there is precedent for it.

Acknowledgments

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Notes

1. Taubert, J. 1975. Pauspunkte in Tafelbildern des 15. und 16. Jahrhunderts. *Bulletin de l'Institut Royal du Patrimoine Artistique* (XV):390.
2. Bruges, State Archives, Aanwinsten 3804: Register van de burgerlijke vonissen van de Schepenkamer te Brugge 1518–1519, fols. 82v–83r. See also Parmentier, R. A. 1937. Bescheiden omtrent Brugsche Schilders in de 16e eeuw: I. Ambrosius Benson. *Handelingen van het genootschap Société d'Emulation te Brugge* LXXX, 92–3. See also Marlier, G. 1957. *Ambrosius Benson et la peinture à Bruges au temps de Charles-Quint*, Damme, 42–43.
3. The *St. Anne Altarpiece* was the subject of the Curatorial Colloquy III of the Center for Advanced Study in the Visual Arts, 20–24 May 1991.
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5. Klein, P. 1986. *Dendrochronological Report on The St. Anne Altarpiece*. 23 April 1986. Klein determined that there are two groups of boards. Three of the boards, two from *St. Anthony* and one from *St. Nicholas*, come from the same tree. The felling date of this tree was estimated as 1496 (using the assumption of fifteen sapwood growth rings). The other group of boards have rings that suggest a felling date of 1402. Assuming the wood was stored for ten years, Klein estimates the altarpiece could have been manufactured from 1506 onward.
6. von Bodenhausen, E. F. 1905. *Gerard David und seine Schule*. Munich: F. Bruckman.
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11. Gettens, R. J., E. W. FitzHugh, and R. L. Feller. 1993. Calcium Carbonate Whites. In *Artists' Pigments: A Handbook of their History and Characteristics*, Vol. 2. Washington: National Gallery of Art, 203–26.
12. Infrared reflectography of the main panels was undertaken (1981–1982) by Molly Faries and in 1990 by Maryan Ainsworth. Reflectography of the Toledo panels was completed in 1984 by Faries, and of the Edinburgh panels in 1990 by the National Gallery of Art. Faries used a high resolution Grundig FA 70H video camera with a TV Macromar 1:2.8/36 mm lens and a Kodak 87A Wratten filter on a Hammamatsu N214 vidicon detector. The assemblies were prepared by photographing the image as it appeared on the monitor and pasting the photographs together.
13. A Leitz Orthoplan microscope was used with apochromat lenses. The samples were mounted in Cargille Meltmount and examined at x100–630.
14. Faries, M. 1986. Division of labour in the production of panel paintings in the workshop of Jan van Scorel. In *Kunst voor de beeldenstorm*. Exhibition catalogue. 's-gravenhage: 113.
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16. Brinkman, P. W. F., L. Kockaert, L. Maes, L. Masschelein-Kleiner, F. Robaszynski, and E. Thielen. 1984. Het lam Godsretabel van van Eyck. Een heronderzoek naar de materialen en schildermethoden. 1. De plamuur, de isolatielaag, de tekening en de grondtonen. *Bulletin Institut Royale Patrimoine Artistique-KIK* (20):137–66.
17. Brinkman, P. W. F., L. Kockaert, L. Maes, E. M. M. Thielen, and J. Wouters. 1988–1989. Het lam Godsretabel van van Eyck een Heronderzoek naar de materialen en schildermethoden. 2. De hoofdkleuren blauw, groen, geel en rood. *Bulletin Institut Royale Patrimoine Artistique-KIK* (20):26–49. See also Coremans, et al., op. cit. and Brinkman, et al., 1984, op. cit.
18. A JEOL 6300 scanning electron microscope and a Link energy dispersive spectrometer with the Super ATW Si(Li) detector were used. Analysis of a green particle in the bottom layer of paint in the cloth of honor showed it was composed of copper, chlorine, and oxygen.
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Abstract

Based on extensive information from cross sections and infrared reflectography, this paper presents some aspects of painting technique that were held in common by Jan van Scorel, the head of a productive sixteenth-century North Netherlandish workshop, and Maarten van Heemskerck, his best-known assistant. Some of the idiosyncrasies in Heemskerck's painting technique differ from Scorel's studio routine and are more apparent in this artist's early works.

Maarten van Heemskerck and Jan van Scorel's Haarlem Workshop

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Introduction

From the records of the Mariakerk in Utrecht where Jan van Scorel held clerical office, the precise dates of his stay in Haarlem are known: 29 April 1527 to 28 September 1530. Karel van Mander's *Schilder-Boeck*, the primary source on the workshop Scorel established in Haarlem during that time, reports that Scorel rented a house in order to take on students. In the biographies of other sixteenth-century North Netherlandish painters, including Jan Swart van Groningen or Jan Vermeyen, Mander implies that these painters were either Scorel's students or were somehow in contact with his shop. Modern scholars have added other likely (and not so likely) names to Mander's list, including Cornelis Buys, Herman Postma, and Jan Stephan van Calcar, but the assistant whom Mander described at some length was Maarten van Heemskerck. According to Mander, Heemskerck applied himself diligently in Scorel's Haarlem studio, eventually producing works that were indistinguishable from those of his master. In Mander's rather dramatic account, Heemskerck finally surpassed the *de Const* (artistry) of his master, only to be dismissed from the shop, ostensibly because of Scorel's jealousy (1). However anecdotal this story might seem, art historians have indeed had difficulties distinguishing early works by Heemskerck from Scorel's work. For most of the twentieth century, early Heemskerck artworks were attributed to Scorel; it was not until the 1980s that several key attributions were changed, primarily in the 1986 Art Before Iconoclasm exhibition (2). Jeff Harrison's recently published dissertation on Heemskerck is the first to outline a new and plausible chronology for his early works (3).

Jan van Scorel's technique

Full technical studies have been carried out by Molly Faries and J. R. J. van Asperen de Boer on a number of paintings by Jan van Scorel from this period, including examination by binocular microscope, infrared reflectography, X-radiography, dendrochronology, and sampling. Until the new shifts in attribution, few early works of Heemskerck had been studied as thoroughly. This situation changed with the recent cleaning of *Lamentation* (Wallraf-Richartz-Museum, Cologne), a painting attributed variously to Scorel, Heemskerck, or an anonymous artist from the same period. The research in conjunction with this restoration, carried out under the direction of Christa Steinbüchel, has

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Figure 1. Jan van Scorel, *Baptism of Christ*, ca. 1527–1530. Photograph by M. Faries (after Dingjan), courtesy of Frans Halsmuseum, Haarlem.

provided critical comparative evidence (4). The results help to define the art historical attributions and suggest some changes to Harrison's chronology. This material not only brought greater clarity regarding the typical painting procedures used in Scorel's shop, but also signaled the steps Heemskerck took in his evolution away from Scorel's shop.

During the Haarlem years, Scorel standardized his painting technique in response to the needs of an active workshop (5). The most overt clue to the standardization is revealed in the layout of underdrawings from this period. The *Baptism of Christ* in the Frans Halsmuseum, Haarlem, must have been one of the most prestigious commissions the artist received 1527–1530 (Fig. 1). The layout of this painting is fully worked out, from the assured contours and loosely marked shaded zones in the figures of the main scene to the light and dark bands in the landscape and other background detail. Areas where a known motif was to be placed were no longer just left as a blank space in the underdrawing, but marked with indicative shapes referring to the motif. The underdrawing was laid out as a more recognizable and emphatic guide.

The *Baptism* was also painted following what had evolved into Scorel's usual practice. This practice comprised the following: (a) an application of lead white as a continuous intermediate layer between the ground and paint, (b) an underdrawing in black chalk on this layer, and (c) a preference for certain paint-layer structures and color combinations. A white intermediate layer certainly occurs in artistic groups other than that of Scorel's workshop. It has been found in some early German panels, and sporadically in the Hans Memling and Gerard David groups, for instance. Scorel, however, could not have learned the use of such a layer from his master in Amsterdam. It begins to show up in some of Scorel's early works produced during his journey to Italy, but only appears consistently after his return north. It was the three-fold function of this layer that was peculiar to the efficacy of Scorel's painting technique: it isolated the ground, added to the painting's luminosity, and provided "tooth" for the underdrawing, a function almost unique to the Scorel group (6). In many infrared documents, the underdrawing can be seen to skip or crumble on top of this ridged surface. One cross section from *Baptism* shows this typical paint layer structure: a first layer consisting of lead white at a maximum thickness of 12 μ , a second layer composed of clumps of black

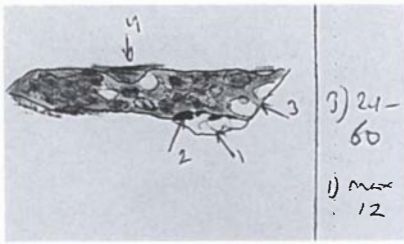


Figure 2. Cross section from *Baptism* with measurements in microns: layer 1, traces of the intermediate white layer; layer 2, particles of black chalk underdrawing; layer 3, mixture of light green, blue, and white. Photograph by M. Faries (after J. R. J. van Asperen de Boer).

underdrawing, and a third layer consisting of a dark green mixture of green, blue, and white; no ground is used (Fig. 2). In addition, Scorel often paints wet in wet with the usual run of pigments, except for his use of natural ultramarine and a blue-over-rose structure. The latter superimposition of colors, with ultramarine on the surface (as seen again in a cross section from *Baptism*), has been linked to Scorel's observation of Italian painting technique (Plate 30) (7).

Marteen van Heemskerck's technique compared

Before the conservation of the Cologne *Lamentation* and the recent revisions in art historical opinion, what was known of Heemskerck's painting technique showed little connection to Scorel (Fig. 3). The current acceptance of *Lamentation*, long attributed to Scorel, as a Heemskerck by scholars Faries, Harrison, and W. Th. Kloek is by no means unchallenged. A study of the painting's technique shows why a separation of "hands" has been so difficult. *Lamentation* was begun as a Scorel studio piece and finished as a Heemskerck, as seen in both the underdrawing and the painting technique. Infrared reflectography examination, undertaken by Faries in 1991, disclosed exceptionally complicated compositional change in this work (8). The painting was taken through as many as six stages while the composition was changed from a profile Scorelesque *Entombment* scene to a Heemskerck frontal presentation of the *Lamentation*.

The numerous samples required because of the piece's complex restoration history provided more than enough evidence about *Lamentation's* painting procedure. The initial preparation of the ground and position of the underdrawing in the paint layer structure match the standard practice of Scorel's Haarlem shop. A thin layer of lead white covers the entire surface of the ground; it appears consistently in sections that show the entire paint layer structure. The black chalk underdrawing is found on top of the intermediate layer (9). Although some of the lines of the different compositional stages must have crossed, no noticeable overlapping or disjunctures in any samples that include the underdrawing layer can be seen. The presence of the lead white intermediate layer coupled with the black chalk underdrawing can be



Figure 3. Maarten van Heemskerck, *Lamentation of Christ*, ca. 1530. Photograph by C. Steinbüchel, courtesy of Wallraf-Richartz-Museum, Cologne.



Figure 4. Infrared reflectogram detail of *Lamentation*, showing the dark undermodeling strokes of Nicodemus's turban in the upper background. Infrared reflectography by M. Faries.

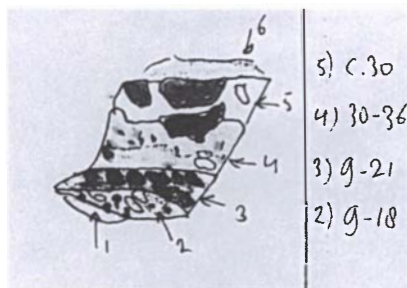


Figure 5. Cross section from Maarten van Heemskerck's *St. Luke* with measurements in microns: layer 1, possible trace of ground; layer 2, gray intermediate layer; layer 3, compact layer of black with black particles; layer 4, admixture of white, black, and red; layer 5, white layer with one large azurite crystal; layer 6, varnish. Photograph by M. Faries (after J. R. J. van Asperen de Boer).

considered a kind of technical signature, although not of an individual hand: It is the signature of Scorel's shop. Most of the pigments used in completing the image are, of course, also common to those found in Scorel's paintings. No ultramarine has been found, however, and the blue used throughout the painting is azurite. This no doubt proves not only that Jan van Scorel is the only north Netherlandish artist documented to have used natural ultramarine in his works, but that he also used it selectively, saving it for his most important commissions (10). It was, therefore, not available to his assistant, or at least not for this painting. Not unexpectedly, the blue-over-rose paint layer structure is also lacking in *Lamentation*.

Other ways in which the painting practice in *Lamentation* deviates from Scorel's standard require a different explanation, since these differences form critical links with other paintings that can now be considered early Heemskerck. Dark modeling strokes executed with a brush have been detected in the finishing stages of *Lamentation*. Some strokes that underlie the surface colors can be disclosed by infrared (Fig. 4). Other black-colored modeling is applied in the final paint layer, especially in reds. The cross section from John the Evangelist's drapery clearly shows the black particles in the vermilion and red lake admixture (11).

Although Scorel's *Baptism* and Heemskerck's *Lamentation* are the focus of this study, their techniques may be compared to a substantial amount of related technical material. Ample evidence proves that the paint-layer structure described above typifies the Scorel group paintings during Scorel's time in Haarlem. In addition, since nine paintings now attributed by some scholars to the early Heemskerck period have also been examined by various technical means, the evolution of Heemskerck's painting technique can be surveyed (12). Of the nine paintings, only four have been studied with the binocular microscope and sampled so far. At least three paintings use the blue-over-rose structure typical of the Scorel group although, in each case, the blue pigment is azurite. Other aspects of the paint layer structure can be documented by X-ray or infrared reflectography. The infrared vidicon distinguishes pure colors that look black to our eyes but are transparent to the eye of the vidicon from "true" blacks, which remain opaque in reflectograms. This instrumental technique can therefore locate black modeling or undermodeling in the same way it locates underdrawings. Dark modeling strokes used to block in forms can also be found in at least three other works in the hypothetical early Heemskerck group. The technique is unknown in the Scorel group. The presence of a thin layer of lead white over the ground can be verified in cross sections, as well as by X-radiography where it appears as broadly-brushed streaking. This practice is evident in a majority of works in the early Heemskerck group. It is the coupling of underdrawing with this layer, however, which undergoes a change; and finally, the character of the layer itself changes. In *Lamentation*, the black chalk underdrawing is supplemented by dark modeling and undermodeling in paint. Several other paintings have a form of underdrawing, but it is executed in a dark, paintlike substance rather than chalk. In four works, the underdrawing is undetectable. No underdrawing could be detected in the *St. Luke Painting a Portrait of the Virgin and Child* (1532), an indisputable early Heemskerck, and no underdrawing appeared in samples. In this work Heemskerck used a gray intermediate layer, a very different basis upon which to build up the forms of his painting (Fig. 5) (13).

Conclusion

Heemskerck must have worked in Scorel's studio for all or part of the period from 1527 to 1530, and after Scorel left Haarlem in September 1530, Heemskerck continued to paint in the city as an independent master until he himself left for Rome in 1532. The artist moved from a graphic black-on-white layout to more subtle forms of shading and undermodeling; based on changes in painting technique, an evolution is proposed for Heemskerck in this period.

The key position of *Lamentation* in this proposed development is obvious, for it encapsulates both painting methods. Generally, those paintings that still rely on underdrawing (on the intermediate white layer) as part of the basic layout have an early date. Whether or not the paintings were produced in Scorel's shop probably cannot be proven, but they were painted following Scorel's shop routine. The paintings without underdrawing but with black-colored modeling appear to be later works, closer to Heemskerck's dated works of 1531 and 1532. A clearer art historical picture of the early Heemskerck is now possible, but surely the blending of Scorel's painting practices into the build-up of some of the earliest works explains the difficulties art historians have had in the past in attributing these paintings.

Notes

1. van Mander, K. 1604. *Het Schilder-Boeck*. Haarlem. Davaco ed. 1969, fol. 245.
2. *Kunst voor de beeldenstorm*. 1986. Exhibition catalogue. Eds. J. P. Filedt Kok, W. Halsema-Kubes, W. Th. Kloek. Amsterdam: Rijksmuseum. Especially catalogue number 69, *Rest on the Flight into Egypt* (National Gallery of Art, Washington, D.C.) and catalogue number 72, *Portrait of a Young Scholar* (Boymans van Beuningen Museum, Rotterdam), which were definitively assigned to Heemskerck. Around this same time, *Adam and Eve* (Hatfield House, Marquess of Salisbury) was being shifted from Scorel to Heemskerck by the research of Faries and Harrison.
3. Harrison, J. C. 1992. *The Paintings of Maerten van Heemskerck*. (Ph.D. diss., 1987, University of Virginia.) Ann Arbor, Michigan, esp. 11–34.
4. For the restoration, see C. Steinbüchel, "The investigation and restoration of Maerten van Heemskerck's *Lamentation of Christ*." In *Le dessin sous-jacent dans la peinture, Colloque X: Le dessin sous-jacent dans le processus de création*, eds. R. Van Schoute and H. Verougstraete-Marcq. Université Catholique de Louvain, Institut supérieur d'archéologie et d'histoire de l'art. Forthcoming.
5. Faries, M. 1987. Some results of the recent Scorel research: Jan van Scorel's definition of landscape in design and color. In *Color and Technique in Renaissance Painting, Italy and the North*. Ed. M. B. Hall. New York, 89–103, esp. 96.
6. van Asperen de Boer, J. R. J., M. Faries, and J. P. Filedt Kok. 1986. Painting technique and workshop practice in northern Netherlandish art of the sixteenth century. In *Kunst voor de beeldenstorm*. Exhibition catalogue. Eds. J. P. Filedt Kok, W. Halsema-Kubes, W. Th. Kloek. Amsterdam: Rijksmuseum, esp. 108.
7. Faries, op. cit., 92.
8. For these infrared reflectography results, see M. Faries, "Attributing the layers of Heemskerck's Cologne *Lamentation of Christ*." In *Le dessin sous-jacent dans la peinture, Colloque X: Le dessin sous-jacent dans le processus de création*. Eds. R. Van Schoute and H. Verougstraete-Marcq. Université Catholique de Louvain, Institut supérieur d'archéologie et d'histoire de l'art. Forthcoming.
9. Sample numbers 1, 2, and 27.1 show this structure. Communication from Christa Steinbüchel to Molly Faries, 7 October 1994.
10. van Asperen de Boer, et al., op. cit., 109.
11. Sample number 18. Communication from Christa Steinbüchel to Molly Faries, 7 October 1994.
12. The works studied, in presumed chronological order, are as follows: ca. 1527–1530: (1) *Lamentation of Christ*, private collection, New York; (2) *Crucifixion*, Detroit Institute of Arts; (3) *Rest on the Flight into Egypt*, National Gallery of Art, Washington, D.C.; (4) *Lamentation of Christ*, Wallraf-Richartz-Museum, Cologne; (5) 1531: *Portrait of a Scholar*, Museum Boymans-van Beuningen, Rotterdam; (6) 1531?: *Baptism of Christ*, Staatliche Museen Preußischer Kulturbesitz, Berlin; (7) 1532: *Christ as the Man of Sorrows*, Museum voor Schone Kunsten, Ghent; (8) 1532: *St. Luke Painting a Portrait of the Virgin and Child*, Frans Halsmuseum, Haarlem; (9) ca. 1530–1532: Family Portrait, Staatliche Kunstsammlungen, Kassel. For the lack of underdrawing revealed in the 1529 so-called Bicker Portraits in Amsterdam, Rijksmuseum, see *Kunst voor de beeldenstorm*, op. cit., catalogue number 71.1–2.
13. van Asperen de Boer, J. R. J. 1987. A technical study of some paintings by Maerten van Heemskerck. In *Color and Technique in Renaissance Painting, Italy and the North*. Ed. M. B. Hall. New York, 105–114.

Abstract

In the 1620s, a generation of Dutch landscape artists began to work in a naturalistic mode very different from that of the earlier generation of Flemish mannerist landscape artists, a number of whom had recently emigrated to the Northern Netherlands. The change from fantastic landscape to representations of Dutch scenes reflected political and economic changes as the Northern Netherlands established independence from Spanish domination. This stylistic change is reflected in changes in the painting materials and practices of the realist painters. In the 1620s, Dutch painters of naturalistic landscape adapted the efficient working practices of the Flemish landscape painters. They replaced the refined handling of paint and bright colors of the mannerist painters with limited tonalities and an abbreviated handling of paint to create convincing views of the Dutch landscape.

Style and Technique in Dutch Landscape Painting in the 1620s

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Introduction

The early years of the seventeenth century saw a striking change of style in landscape painting in the Netherlands. At this time, Flemish landscape specialists produced paintings characterized more by fantasy than by close observation of nature. In the 1580s and 1590s, large numbers of Flemish artists, some of them landscape specialists, had emigrated to Holland to escape the political and economic hardships of the rebellion against Spanish rule (1). Around 1620, a very different, naturalistic style of landscape painting developed in the Northern Netherlands, particularly around Haarlem. These paintings, often based on drawings after nature, created distinctive images of the Dutch landscape (2, 3, 4).

Such a dramatic change of style raises fascinating questions about how style develops. Was the new, naturalistic landscape style sparked by the arrival of the Flemish immigrants, or does it reflect an indigenous artistic sensibility? Is artistic style dependent on painting practice learned from other artists, or do artists modify their practice to meet the demand for new styles?

In an ongoing technical study, the author has been looking for material evidence for landscape artists' artistic concerns (5). This study seeks to characterize the differences of technique between Flemish mannerist landscapes of the turn of the sixteenth and seventeenth centuries, landscapes by Flemish immigrants to the Northern Netherlands during the same period, and the first naturalistic Dutch landscapes, which date from the second and third decade of the seventeenth century (6). In defining the artists' choices of working methods and painting materials, the study seeks to expand our understanding of the motivations, both formal and practical, behind the development of the naturalistic Dutch landscape in the 1620s. The present contribution centers on developments in the handling of paint in these landscapes. From the paintings studied to date, I have chosen five paintings as illustration: a Flemish mannerist landscape, a mannerist landscape by a Flemish immigrant, two naturalistic landscapes by Dutch artists, and a somewhat later Dutch "tonal" landscape. A later, more complete publication will present full analyses of the paintings' materials.

Flemish mannerist landscape

In the Flemish landscape painting tradition, space is defined by formal conventions that convey an illusion of recession. Dark and light passages alternate, often with shadowed foreground *repoussoirs* sharply outlined against a brightly lit area beyond. Optical phenomena such as atmospheric perspective are represented not illusionistically, but almost symbolically, by a space organized into three zones defined by distinctly different tonalities. The darkened foreground zone is typically a rich brown, the middle ground is green, and the distance is a clear blue.

Study of the technique of Flemish mannerist landscapes reveals refined handling combined with efficient working methods, which contributed to the high output of busy workshops. The compositions were usually laid out with a fairly complete underdrawing, most often including the figures, which were planned as integral parts of the composition. With the underdrawing as guide,



Figure 1. Workshop of Jan Bruegel, Noah's Ark. Panel, 65.4 × 94.5 cm. The Walters Art Gallery, Baltimore (37.1998).

space for the figures was left in reserve as the landscape was painted. Some landscape specialists collaborated with figure painters, in which case the figures would be painted over a fully completed landscape. Other workshops divided up production in a sort of assembly line, with junior associates filling in minor details.

The painting materials in the Flemish mannerist group, while not unusual, were used in ways that enhanced the clear colors. Typically, a light-colored, opaque ground maintained the luminous tonalities of the paint, but rarely is the ground itself visible in the final image. Instead, the three dominant zones of the composition were laid out with broad areas of underpaint: warm brown in the foreground, soft green in the middle zone, and light blue in the distance. The final image was worked up over these base colors. Working from the back of the composition to the foreground, each zone was painted in turn in a limited range of colors harmonizing with that of the underpaint.

A painting of *Noah's Ark* at the Walters Art Gallery was produced by the workshop of Jan Bruegel (Fig. 1) (7, 8). In this painting, the techniques described above were adapted for team production in a workshop setting. As shown in a paint cross section from high in the central group of trees, a thick white chalk ground was sealed and lightly toned by a translucent imprimatura (layers 1 and 2) (Plate 31) (9). Over the preparation and underdrawing, the sky was laid in first, followed by a base color loosely brushed for each particular area of the composition; the upper two layers of the cross section show the sky (layer 3), which extends under the foliage base tone in the upper part of the trees, and the clear green underpaint (layer 4) of the lightest passage of the central group of trees. A skilled painter painted the main foliage elements and the figures and animals, which are the primary subjects of the painting, onto the broad areas of underpaint. Only after these major elements



Figure 2. Roelandt Savery, *Landscape with Animals and Figures*, signed and dated 1624. Panel, 54.6 × 91.4 cm. National Gallery of Art, Washington, D.C. (1989.22.1). Gift of Robert H. and Clarice Smith in honor of the fiftieth anniversary of the National Gallery of Art.

were completed did a workshop assistant fill in minor foliage details. The assistant's work has a mechanical, repetitive quality, and shows a cautious respect for the work of the master; the monkey on a low branch at the left is surrounded by a halo of the base color, where the assistant scrupulously avoided overlapping the master's work with his blades of grass.

Landscapes by Flemish immigrants

Landscapes by Flemish immigrants such as Gillis van Coninxloo, who arrived in Amsterdam from Frankenthal in 1595, and Roelandt Savery, who arrived with his family in 1591, are clearly in the Flemish tradition, both compositionally and technically (10). There are, however, variations of emphasis in the compositions that have consequences for the technique. The compositions retain the conventions of Flemish landscape. Dark and light passages are strongly juxtaposed and the three zones in brown, green, and blue organize the recession into space, but there is a much greater emphasis on the nearer zones. In Coninxloo's forest landscapes, such as the *Landscape with Hunters* of 1605 in Speyer, the second and third zones are reduced to glimpses caught through the dense growth of monumental trees that fills the foreground zone (11). The result is a newly limited tonal range, one that emphasizes the browns and deeper greens of the middle and foreground. This self-imposed limitation is in itself a first step toward naturalism.

The techniques of these immigrant artists are consistent with contemporaries still working in Flanders. The compositions were planned in underdrawings that made provision for all but the minor figures. Over a light-colored ground the artists established a base color for each area with a brushy underpaint; each area was then worked up with loosely painted, final details in a color that harmonized with the underpaint showing through from below. To avoid the danger of monotony in their emphasis on the brown foreground and green middle zones, the artists introduced a range of subtle variations within the harmonies of browns and greens.



Figure 3. Cornelis Vroom, *Landscape with a River by a Wood*, signed and dated 1626. Panel, 31.3 × 44.2 cm. National Gallery, London (3475).

In Roelandt Savery's *Landscape with Animals and Figures* (1624), an area for the foreground group of figure and animals was held in reserve while the landscape was painted; only the small figures to the rear are painted over the landscape (Fig. 2). The foreground of this work is painted with final details in a typical transparent brown over a warm brown underpaint. In the lighter middle ground of this painting, the same transparent brown is used for the details over passages of tan underpaint; in a passage underpainted in gray, such as the stream at the left, the details are worked up in rapidly sketched strokes of darker gray paint.

Landscape in Haarlem in the 1620s

By the 1620s, a number of Dutch painters had taken up landscape as a specialty. In contrast to the fantasy landscapes of the Mannerists, these paintings represented recognizable scenes of the local countryside. The colors are limited, the compositions rely on subtle atmospheric effects to create almost continuous recession into space, and the figures no longer play a significant role. The techniques of landscape painting in this early period are varied, but there is evidence that those Haarlem artists who were most adventuresome compositionally also incorporated new ways of handling paint, methods which became integral to the effects of the "tonal landscape" painters in the 1630s.

Cornelis Vroom painted the *Landscape with a River by a Wood*, a work now in London, in 1626 (Fig. 3). This Haarlem landscape artist did not participate in the tonal style in the next decade, but in this early landscape, Vroom modified Flemish practice to create a more subtle spatial recession with his characteristic color range dominated by browns, yellows, and grayish greens. The color of each area is established using an underpaint, following the Flem-



Figure 4. Esaias van de Velde, *Winter Landscape*, signed and dated 1623. Panel, 25.9 × 30.4 cm. The National Gallery, London (6269).

ish practice, but this underpaint is more varied, not restricted to sharply defined bands of color receding into the composition. Throughout the foreground and middle ground the underpaint is a web of grayish green and yellow passages, worked wet-into-wet.

The landscape paintings of Esaias van de Velde, produced during his years in Haarlem (1609–1618) and in the Hague until his death in 1630, are central to the development of the naturalistic landscape. Though Esaias was trained by the Flemish immigrant Gillis van Coninxloo, he developed most of the elements of technique that were to define the work of the naturalistic tonal landscapists, who included his pupils Jan van Goyen and Pieter de Neyn. This is particularly apparent in his winter scenes, where the bare landscape encourages a particularly limited tonality. The *Winter Landscape* of 1623, now in London, is prepared with a thinly rubbed ground that barely fills the grain of the oak panel (Fig. 4). A cross section from the upper edge of the sky shows this extremely thin layer, textured on the underside by the grain of the wood (layer 1) (Plate 32). This preparation is barely perceptible on the painting; the warm pinkish tone that dominates passages, such as the distance at the right and parts of the foreground, is created by the wood showing through the slightly tinted ground (12). In a loose and suggestive underdrawing, the artist situated the main elements of the landscape and indicated the foliage along the horizon with a few looped strokes but made no provision for the figures (Fig. 5). Following the guide of the underdrawing, he toned



Figure 5. Infrared photograph of Esaias van de Velde's *Winter Landscape*. National Gallery, London (6269).

broad areas of the composition, leaving the panel's thinly applied ground visible in places. At this stage, the sky was painted with varying concentrations of pale smalt (layers 2 and 3), and the details of the horizon were painted wet-into-wet; forms in the foreground were sparsely indicated with tan and gray-green underpaint. Over this underpainting the artist sketched out the details of the image in a monochrome paint ranging from gray to black, then completed the painting with a few touches of creamy mid-tones and final highlights painted wet-into-wet. When the entire landscape was complete, the artist superimposed the small figures over it, the human presence almost incidental to the depiction of a raw winter's day.

The tonal landscape painters

At the end of the 1620s, Jan van Goyen and two other Haarlem artists, Pieter Molijn and Salomon van Ruysdael, initiated a landscape style in which a completely convincing representation of the Dutch countryside was rendered in a deliberately limited, almost monochromatic palette. A work as late as van Goyen's *View of Dordrecht from the Dordtse Kil* (1644) reveals the economy of handling that typifies these works: a wet-into-wet application of the sky and horizon, followed by a sketchy monochrome design only occasionally amplified by rapid touches of lightly colored paint (Fig. 6). The tone of the wood and the grain pattern can be seen through the thin ground; both play a role in the final image. The results of an earlier technical study established



Figure 6. Jan van Goyen, *View of Dordrecht from the Dordtse Kil*, signed and dated 1644. Panel, 64.7 × 95.9 cm. National Gallery of Art, Washington, D.C. (1978.1.11). Alicia Mellon Bruce Fund.

that both the visible wood grain and the monochromatic palette, especially the use of almost colorless smalt in the grayish skies, resulted from conscious artistic choices rather than accident (13). The rapidity with which these works must have been painted may have had an economic motive as well, lowering the cost of production and hence enlarging the market for such works (14).

Conclusion

The transition from Flemish mannerist landscape to a new Dutch form of naturalistic landscape in the first decades of the seventeenth century represents a dramatic transition in style. The mode of mythological or biblical episodes set before brightly colored, imaginary vistas, which Flemish immigrants had brought north, was replaced in Holland in just a few years by subdued and sympathetic renderings of the Dutch countryside.

The preliminary results of this study of the painting techniques of the period suggest that the change in style was accomplished by deliberate changes in painting technique. Dutch artists modified the conventionalized Flemish landscape technique of light grounds, complete underdrawings, and colored underpaints, which established three schematic zones of space. Instead, working from drawings made from nature, they developed a sketchy shorthand style in which the properties of their painting materials were exploited to evocative effect. Thinly applied grounds and spare applications of underpaint allowed the panels themselves to play a role in the image. Underdrawings became quick notations upon which a more complete painted “sketch” was developed, and this monochrome image, only partially colored and worked up in the final stage of painting, was a dominant part of the finished work.

These developments are a fascinating illustration of the ways in which political and social changes foster new artistic markets. As members of Dutch society

at the beginning of the seventeenth century, naturalistic landscape painters must have shared with their fellow citizens a newly awakened appreciation for the beauties of the local scene. As business people, they supplied and developed a new market governed by this taste. As practitioners of painting, they developed new working methods, which were both economical and superbly suited to expressing their new aesthetic.

Notes

1. Briels, J. G. C. A. 1976. De zuidnederlandse immigrantie in Amsterdam en Haarlem omstreeks 1572–1630. Ph.D. diss. Rijksuniversiteit Utrecht.
2. Bengtsson, Å. 1952. *Studies on the Rise of Realistic Landscape Painting in Holland 1610–1625*. Figure 3.
3. Brown, C. 1986. Introduction. In *Dutch Landscape, The Early Years: Haarlem and Amsterdam 1590–1650*. Exhibition catalogue. London: The National Gallery, 11–34.
4. Freedberg, D. 1980. *Dutch Landscape Prints of the Seventeenth Century*. London.
5. I am grateful for the opportunity to have studied paintings in the collections of the Frans Halsmuseum, Haarlem; the National Gallery, London; the National Gallery of Art, Washington; and the Walters Art Gallery, Baltimore. I would particularly like to thank Ashok Roy of the National Gallery and Ella Hendriks of the Frans Halsmuseum for their assistance. I appreciate very much the many discussions of this material that I have had with Arthur K. Wheelock, Jr. Paintings included in the study were examined with a stereomicroscope, and with X-radiography and infrared reflectography, where available. Paint analysis was carried out on a limited number of dispersed pigment samples and paint cross sections by light microscopy and scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS). The compositions of paint mediums were estimated only using biological stains on the cross sections. Additional paintings were examined visually to study the handling of paint.
6. A survey of several Dutch landscapes from the 1620s and the “tonal” period can be found in Bomford, D. Techniques of the early Dutch landscape painters. In Brown, op. cit., 45–56.
7. This painting was sampled by Felicity Campbell during conservation treatment in 1988.
8. This painting closely replicates the primary version now at the J. Paul Getty Museum, Malibu (92.PB82).
9. From the samples, it is not clear whether the underdrawing lies under or over the imprimatura.
10. Coninxloo died in 1607. Savery left Amsterdam for Prague, where he served the Emperor Rudolf II until about 1613, when he returned to Amsterdam. In 1619 he moved to Utrecht, where he worked until his death in 1639.
11. Historisches Museum der Pfalz, Speyer (H. M.1957/122). Illustrated in Sutton, P. C. 1987. *Masters of Seventeenth-Century Dutch Landscape Painting*. Exhibition catalogue. Amsterdam: Rijksmuseum; Boston: Museum of Fine Arts; Philadelphia Museum of Fine Arts. Plate 1.
12. A ground of black, toned with a little yellow earth and rubbed into the poplar support, was observed on the original section of *Farms Flanking a Frozen Canal*, 1614, North Carolina Museum of Art, Raleigh (52.9.61). See Goist, D. C. 1990. Case study of an early Dutch landscape. *ICOM Committee for Conservation preprints*, 9th Triennial Meeting, 648–52.
13. Gifford, E. M. 1983. A technical investigation of some Dutch seventeenth-century tonal landscapes. *AIC preprints*, 39–49.
14. Montias, J. M. 1987. Cost and value in seventeenth-century Dutch art. *Art History* 10:455–66.

Abstract

Through extensive study of Vermeer's paintings, the author demonstrates that the artist must have used a chalk line attached to a pin at the vanishing point in the painting to create the central perspective in his pictures. By studying the changes in the design of the central perspective throughout his oeuvre, a certain chronology appears. This conclusion contradicts the previously accepted beliefs that Vermeer's interiors were faithful portraits of actual rooms or that the use of a camera obscura explained the realism of his interiors.

Johannes Vermeer (1632–1675) and His Use of Perspective

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Introduction

After visiting Vermeer on 21 June 1669, the art collector Pieter Teding van Berckhout noted in his diary that, among the examples of Vermeer's art he had seen, the most extraordinary and curious were those showing perspective (1). Three-dimensional interiors, depicted on two-dimensional canvases in such a way that the eye is deceived into believing the spatial illusion, were greatly admired by *liefhebbers* (connoisseurs) in the seventeenth century. The appreciation of perspective was underlined by the fact that these paintings had to be executed by artists who were sufficiently technically competent to be able to create these effects convincingly (2). Architectural pictures or "perspectives" were therefore often much more expensive than other genres. Montias documented that around 1650, the price for a perspective was fairly high, at an average of 25.9 guilders apiece, while landscapes sold for an average of 5.6 guilders each (3). The Delft architecture painter Hendrik van Vliet (ca. 1611–1675) could have observed that one of his perspectives, in the estate of the art dealer Johannes de Renialme in Amsterdam at his death in 1657, was valued at 190 guilders (4).

Montias states that despite the fact that interior scenes could also rightfully be called perspectives, he never came across a description of one in the many inventories he examined (5). All the more interesting then is the comment van Berckhout made after visiting Vermeer's atelier.

When the inventory of Vermeer's estate was carried out after his premature death in 1675, a number of books in folio were found in his back room together with twenty-five other books of various kinds. Among the easels and canvases in his atelier, three bundles of all sorts of prints were found (6). It might be interesting to speculate what these books and prints were about, but we shall never know. It is conceivable, however, that some of them were guides to perspective drawing, works either by Hans Vredeman de Vries (1526 or 1527–1606) or those published by S. Marolois (ca. 1572–1627), Hendrik Hondius (1573–1649), and F. Desargues (1593–1662) (7, 8, 9, 10). It can be seen in the perspective design extrapolated from his paintings that Vermeer was certainly familiar with the principles laid out in these manuals on perspective.

Unfortunately, nothing is known about Vermeer's apprenticeship. Therefore one must turn to an extensive examination of his paintings in order to gain an impression of the development of his method of rendering space.

State of research

Over the years many studies have been made of Vermeer's use of perspective and his spatial constructions, only a few of which shall be referred to here.

Early this century, Eisler made an extensive study of Vermeer's use of space, and he describes the complicated use of triangles, circles, squares, and diagonals that may have formed the basis for Vermeer's pictures (11).

Probably inspired by Wilenski, who in 1928 wrote about some special effects in photography, ". . . perhaps one of the ironies of art history [is] that with a Kodak any child might now produce by accident a composition that a great

artist like Vermeer had to use all his ingenuity . . . to achieve . . .” Swillens published his first detailed study of the paintings in 1929. Swillens concluded that Vermeer had painted his oeuvre in five different rooms, all thoroughly recorded (12, 13). In another publication on Vermeer in 1950, he further elaborated his views on Vermeer’s use of spatial illusion and his realistic recording of space (14). Swillens illustrated how Vermeer depicted his interiors with great accuracy. The position or eye level of the artist was established and thus the height of Vermeer himself and of the chair on which he almost always sat when painting. The work of Swillens, and belief that Vermeer rendered what he actually saw in front of him, has had a major influence on the scholarly research on Vermeer.

Even in the 1940s, Hyatt Mayor records that highlights in the foreground in some of Vermeer’s paintings “break up into dots like globules of halation swimming on a ground glass,” and a few years later Gowing reached the conclusion that Vermeer had used a camera obscura (15, 16).

In his studies, Seymour continues with this thought, which, apart from halation around highlights, he based on specific phenomena in the paintings, such as the diffusion of the contours (17). He also found that the perspective in certain paintings resembled the distortion obtained when using a wide-angle lens.

Prompted by Seymour’s article, Schwarz further suggested that Vermeer may have used the camera obscura as a technical aid in his painting process (18). Bearing testimony to Vermeer’s use of technical devices for rendering his images, wrote Schwarz, is the fact that the mathematician and physicist Balthasar de Monconys (1611–1665) attempted to visit Vermeer during his stay in Delft in 1663, and that a friendship probably existed between Vermeer and fellow townsman Anthony van Leeuwenhoek (1632–1723), a specialist in microscopes and lenses.

There is a tendency to consider mathematicians otherwise uninvolved in the creation of visual arts as responsible for developing an intellectual interest in perspective. However, this view was probably not shared by the artists, who, for their part, were using the simplest and at the same time most convincing methods to create their spatial illusions. We are therefore entitled to believe that, as de Monconys was also an art collector, it would be much more likely that he wanted to pay Vermeer a visit in order to see his renowned paintings or perspectives (19). Vermeer was also the Headman of the Guild of St. Luke at the time, and he would naturally be the person for an art collector to see when visiting the town.

In 1968 Mocquot suggested that Vermeer might have used double mirrors to create his perspectives, both in his *Allegory of Painting* and in *The Concert* (20, 21, 22).

Finck claimed in 1971 to be able to prove that twenty-seven paintings by Vermeer must have been made with the aid of a camera obscura (23). The arguments presented here will make it clear that this highly ambitious thesis has no basis in reality.

Wheelock undertook the most detailed study of the optics and perspectives used by Delft painters around 1650 (24). It is argued that some of Vermeer’s pictures (although far fewer than is asserted by Finck) do indeed have many effects similar to that which can be achieved using lenses or a camera obscura, and therefore the use of these devices seems highly probable. Wheelock does make clear, however, that the use of a camera obscura would be extremely difficult indoors because the light levels were generally insufficient to obtain an image. In more recent publications, Wheelock increasingly argues that Vermeer probably did not trace images seen through a camera obscura, but that he must have been aware of the device and used certain special effects seen through it for his paintings.

Based on intensive studies of various means used to create “church portraits,” de Boer concluded in 1988 that optical devices were not generally used by artists in the Netherlands around 1650 (25). Interestingly, he notes that the reason for this would probably be the difficulty of combining the use of a camera obscura (for tracing an image) with actually painting a painting.

Recently, Arasse made a general comparison of the position of the horizon and the viewpoint in Vermeer paintings (26). He notes that the viewpoint gradually lowered between 1656 and 1661. According to Arasse, Vermeer tended to combine a low viewpoint with a high horizon. Arasse considers the often very low viewpoint in relation to the depicted figures to be a special effect that Vermeer deliberately wanted to create in order to draw the viewer into the scenes. This statement shows that Arasse considers Vermeer’s intention to be the creation of an illusionistic spatial setting as an imaginative process rather than the rendering of a known space, an opinion this author shares.

Present research

In the following paragraphs, results from the author’s latest research on this aspect of Vermeer’s painting technique are presented. Through a thorough study of the actual paintings, mostly out of their frames and placed under a stereomicroscope, certain surface phenomena in the paint layer have been observed. Together with X-radiographs and other photoanalytical means such as ultraviolet and infrared photography, a compilation of information has been possible, leading to the conclusion that Vermeer did not paint “naar het leven” (after life), as suggested by the majority of scholars mentioned above, but that as a craftsman he created a spatial illusion with the masterly hand of an outstanding artist.

In 1949 Hultén was the first to actually record a discernible vanishing point in one of Vermeer’s paintings. He observed that just below the left knob of the map hanging on the rear wall in *The Allegory of Painting* there was a small irregularity in the paint layer which coincided with the central vanishing point of the composition (27).

Indeed, for Vermeer the central perspective was the main guideline for his interiors. Current examinations reveal that the vanishing point can still be found in most of his interior scenes (28). It can be seen (with the naked eye or more easily with a stereomicroscope) that Vermeer must have attached a pin at the vanishing point in the painting, resulting in the loss of minuscule amounts of paint and ground. X-radiographs can be used to find the black spot where the ground containing lead white is missing between the threads of the canvas. Having inserted the pin at the vanishing point, Vermeer would have used a string to reach any area of his canvas to create perfect orthogonals for the perspective.

Vermeer’s method is far from unique; among the architectural painters of his time it was well known. Gererd Houckgeest (1600–1661) and Emanuel de Witte (1617–1692) practiced this method, which Pieter Saenredam (1597–1665) had already brought to perfection (29, 30). Vermeer’s slightly older colleague Pieter de Hooch (1629–1683) also used a single vanishing point. Similarly, in paintings by Gerard Dou (1613–1675), Gabriël Metsu (ca. 1629–1667), and others, we again find irregularities in the paint where a pin was placed at the vanishing point.

The method of using a chalk line to indicate lines is still used by painters and other artists when planning illusionistic interiors (e.g., with marbling, a specialty developed during the Baroque period). That this kind of illusionistic painting was known to Vermeer is clear from the virginals in the two London paintings, both of which have been “marbled.”

In order to transfer the line indicated by the string, chalk is applied to the string. Holding the string taut from the pin inserted at the vanishing point,



Figure 1. Perspective drawing of Vermeer's *Glass of Wine*, 1658–1660.

the painter draws the string up a little from the surface, using the free hand, and lets it snap back onto the canvas. The powdery chalk is thus applied to the surface of the painting; the line can be traced with a pencil or brush. The remaining dust can be gently wiped or blown away, leaving little or no trace of the method except the pin point.

The distance points, positioned on either side of the vanishing point on the horizon, provide the basis for the diagonals, which in turn form the basis of the tiled floors. Distortion occurs at the corners if the horizon is placed relatively high and the distance points are close to the vanishing point. Examples of this are observed in the *Glass of Wine* (1658–1660), with its viewing angle of approximately 43° (Fig. 1), and the *Girl with The Wine Glass* (1659–1660), which has an even smaller angle of approximately 35° (31, 32). *The Music Lesson* (1662–1665), in which Vermeer again returns to a large angle, (approximately 44°), is the last picture in his oeuvre to show a certain distortion of the floor tiles due to the short interval from the distance points (33). In *The Concert* (1665–1666), the angle again returns to about 34° ; in *The Allegory of Painting* (1666–1667), the viewing angle has decreased to around 30° (Fig. 2). In *The Love Letter* (1667–1670) the angle declines to about 28° , and in the last painting executed by his hand, *A Lady Seated at the Virginals* (1673–1675), Vermeer reduces the viewing angle to only 22° (Fig. 3) (34, 35).

A growing tendency can clearly be observed over the years to let the distance points move further away from the scene. By doing this, Vermeer eliminated the distortion of the floor tiles in the foreground corners, particularly as he moved his vanishing point toward the edge of the painting at the same time.

As the vanishing point can still be identified in many of Vermeer's pictures, his method of using threads attached to a pin inserted at the central point is evident. The distance points, however, could constitute a problem. Would he be able to determine the position of the diagonals on the edge of his canvas when space recedes towards the back walls in his interiors? This is hardly

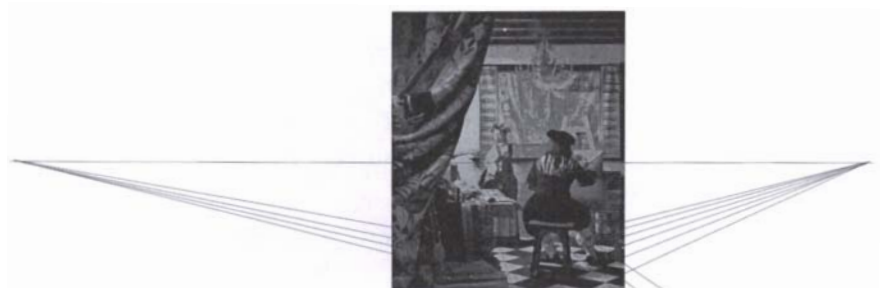


Figure 2. Perspective drawing of Vermeer's *Allegory of Painting*, 1666–1667.

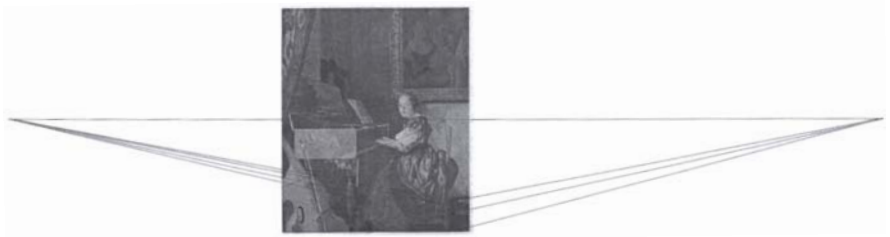


Figure 3. Perspective drawing of Vermeer's *A Lady Seated at the Virginals*, 1673–1675.

likely because it would imply doing unnecessary calculations, and indeed no trace of marks on the edges of his paintings has so far surfaced.

If there were a simple method of creating perfect central-point perspective, painters would surely have used it. By placing the canvas against a board (most of his paintings are small) or a wall, between two nails on either side of the painting, the painter would be able to use strings for the diagonals as well.

Indications of the use of such a simple method may be deduced from books on perspective that might have been known to Vermeer. Desargues writes in his introduction that a painter who wants to know more about the *Meet-konst* (the art of measurement) should consult the *Landmeeter* (the cartographer) in order to make use of his expertise (36). This, he writes, would lead to a better understanding of perspective or *Doorsicht-kunde*. Desargues further suggests that the painter should look around him in other guilds to take advantage of the knowledge of carpenters, bricklayers, and cabinetmakers.

Furthermore, it appears that constructors of perspective in the seventeenth century were using drawing tables almost as sophisticated as the ones we use today. With strings attached to the upper corners of the drawing table, the draftsman could create any orthogonals he wanted on his paper. The horizon could be plotted using a sliding ruler at a fixed 90° angle to the horizontal bottom edge of the table. A horizon would be chosen at the desired level on this ruler, and by sliding the ruler across the paper, a line could be drawn (37).

Vermeer also worked in this way, as is proven by the presence of the clearly distinguishable needle point found in the paint in paintings throughout his whole oeuvre (38).

Conclusion

The extraordinary and curious perspectives, so much admired by van Berckhout in 1669, therefore appear to have been carefully constructed. This leaves the impression that Vermeer should be regarded first and foremost as a practical and skilled master in creating space just the way *he* wanted it. This approach departs from the previous conception of the artist as reproducing the scenes he saw in front of him, either by careful copying using drawing frames or a camera obscura. The author believes that Vermeer was completely aware of the spatial illusion he wanted to create, which he produced by combining his skill in constructing space with his artistic talent for composition, color, technique, and iconography (39). He thereby created his images in such a way that viewers are deceived into believing that the scenes were real. This was the highest level of artistic ambition to which a seventeenth-century painter could aspire, a level Vermeer surely attained.

Acknowledgments

Most sincere thanks are due to the institutes that have been more than generous in supplying information about their Vermeer paintings and letting the author examine most of them in the conservation studios. The amount of information is overwhelming and goes well beyond the scope of this article; the reader is referred to the forthcoming exhibition catalogue on Johannes Vermeer (Washington, 1995; The

Hague, 1996). The author is also grateful to Rob Ruurs of the University of Amsterdam for a fruitful and stimulating discussion.

Notes

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33. H. M. Queen Elizabeth II, Royal Collection, London.
34. Rijksmuseum, Amsterdam.
35. The National Gallery, London.
36. Bosse, op. cit.
37. Ibid.
38. From *Officer and Laughing Girl*, ca. 1658 (The Frick Collection, New York), to *A Young Woman Standing at the Virginal*, ca. 1673–1675 (The National Gallery, London).
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Abstract

The paper presents some results of research on the painting materials and methods used in Latvian churches in the seventeenth century. The technical research of historical painting techniques in Latvia is rather preliminary. The authors concentrate on the polychromy of the interior decorations. Results of the analysis of materials and techniques used in the decorations are given, stressing the varieties as a result of the various interpretations of the Baroque style and technique in different regions of Latvia.



Figure 1. The pulpit and the altar of the Nurmuizha church before restoration. Photograph by M. B. Vanaga and R. Kanins.



Figure 2. The pulpit of the Burtnieki church before restoration. Photograph by M. B. Vanaga and R. Kanins.

A Technical Study of the Materials and Methods Used by the Painters of the Latvian Churches in the Seventeenth Century

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Introduction

In the second half of the seventeenth century, the territory of Latvia was ruled by several different monarchs and was therefore divided into areas of various influences. From the middle of the sixteenth century, the western part was ruled by the Duke of Kurzeme and Zemgale; after the Polish-Swedish war the southeastern part (Latgale) was subject to the Polish king and the northeastern part (Vidzeme) to the Swedish king. These conditions influenced the production of Latvian art. Created by artists coming from various parts of Europe, general styles and tendencies were interpreted in various ways (1). Therefore, the objects of this survey—the churches and their pulpits in Nurmuizha and Burtnieki, both decorated in the 1680s and representative of the Baroque—illustrate two different styles using very different techniques and materials.

The church of Nurmuizha is located in the territory of Kurzeme and was founded in 1594; however, the present interior dates from the 1680s. Twisted columns with rich decorative carvings and many sculptures portraying disciples of Christ decorate the pulpit and the church interior. A sculpture of Moses functions as support for the pulpit. The artist who executed the wood carving is unknown but his style indicates an eastern Prussian origin. Although written contemporary sources do not shed any light on when the decorations were painted, one must assume that it was carried out in the 1680s. Later repairs are relatively extensive, including additional wood carvings and paintings executed by different craftsmen, such as gilders and interior painters (Fig. 1).

The church of Burtnieki is located in the northeastern part of Latvia which was under the rule of the Swedish king. Here, the basic construction of the pulpit is very similar to construction of the pulpit in Nurmuizha, but the decoration is more restricted, rational, and even classical. Baroque influences arrived here by many different routes, thus resulting in a large variety of interpretations. In both churches, pulpits are situated under the arch of triumph. In Burtnieki, however, the pulpit's construction is polygonal with straight stairs, and the columns are not twisted but straight and narrow. The sides of the stairs are decorated with panels separated by pilasters instead of columns. Instead of sculptures, there are paintings on the panels between the columns, all representing scenes from the New Testament. In contemporary documents (1691), it is noted that the altar and the pulpit were painted and outlined with silver. During the present restoration, a rather neutral overpainting was removed, revealing the original decorative painting, which shows

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marbled columns, multicolored paintings on the panels, and blue and silver paintings on the podium. The identities of the artists are unknown (Fig. 2).

Methods

Analysis of the pigments was carried out combining optical microscopy, microchemical tests, and emission spectroanalysis (2, 3). Media were determined by the use of thin-layer chromatography, infrared spectroscopy, and microchemical tests (4, 5, 6).

Materials and results

Technical analysis from paint samples was executed to reveal the original layer of the pulpit of the Nurmuizha church. Samples were taken from the background and profiles of the pulpit's twisted columns (now black) and from the decorative wood carvings of grapes, masks, and reliefs (now gold). The results indicate that the ground layer consists of an unpigmented calcium carbonate bound with an animal glue, as was shown by staining tests. In the cross section, the ground layer is shown as a white layer with some small brown glue particles. On a thin transparent layer in which protein has been found, there is a black layer with occasional particles of a blue pigment. The few blue particles present are transparent; a positive identification of the pigment was impossible. Later overpaintings are executed in black, containing charcoal and oil. The decorative vines are gilded. The underlayer is composed of calcium carbonate and glue. In the cross section, a layer of brown hematite is visible and the presence of glue particles was determined with staining tests. On top of the gilding there is a layer of mordant gilding: oil pigmented with ochre and minium, the latter probably acting as a drying agent. The bronze layer on the pigmented oil layer was applied much later.

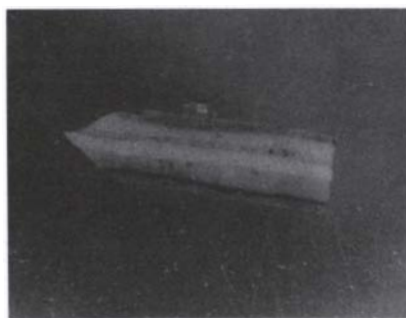


Figure 3. Cross section of paint sample from part of the flesh color on a sculpture in the Nurmuizha church. The layers are as follows: (1) thin pink ground, (2) main paint layer containing lead white and ochre, (3) transparent layer containing oil, (4–8) overpaints. Photograph by M. B. Vanaga and R. Kanins.



Figure 4. Cross section of paint sample from part of the podium in the Burtnieki church. The layers are as follows: (1) thin pink ground, (2) layer of silver leaves, (3) green layer containing cupric resinate, (4–8) overpaints. Photograph by M. B. Vanaga and R. Kanins.

Samples were taken from the clothes, hair, and flesh color of one sculpture on the pulpit (Fig. 3). The analyses showed that the gilded wrap was executed in a water-gilding technique, while the dress itself was originally blue. The blue layer consists of lead white and smalt with tempera as a binding medium on a chalk-glue ground layer (7). Analysis of the samples taken suggests that the pulpit had water-gilded, wood-carving details on a blue background. The same blue color is also found in other details of the church's decoration (the altar and the decorative ledge). Later overpaintings, however, have penetrated the original, damaged layer, changing it and making a correct analysis difficult.

During the technical investigation of the pulpit of Burtnieki church, samples were taken from parts that were well conserved: the background of the pulpit's construction, the podium's decorative ledge, the decorative grapes, the roof, and the pelican. The results of the analysis show that the pink background contains hematite and occasional particles of calcium carbonate (CaCO_3) in oil (Fig. 4). Colors from the original marbling are revealed in the background (smalt, indigo, hematite, charcoal black, and copper resinate). Decorative elements are silvered, such as the silver leaves, which were glazed with copper resinate over the pink underlayer (hematite, oil).

The decorative bunch of grapes is painted in a dark blue layer containing indigo, smalt, and oil, and the green leaves are executed in a green glaze (copper resinate, oil, gum) over silver leaf applied in an oil-based mordant technique. The decorative details of the pulpit's baldachin have the same preparatory ground layer as the podium. The marbling is carried out as described above. The silvering is done using an oil mordant and subsequently glazed. In some places the silver is covered with colorful glazes (i.e., the drops of blood on the pelican are executed in an organic red glaze on silver). In summary, the decorative painting of the Burtnieki church shows a rich polychromy and is executed in an oil medium.

Summary

We can conclude after this preliminary investigation that many differences between the two pulpits are present, although they both date from the same period. Two types of grounds were found; in the Nurmuizha pulpit, chalk-glue ground is used, while in the Burtnieki pulpit a ground of ochre in oil is present. The pigments are similar in that they are probably the most commonly used pigments in Latvia during that period. During previous investigations of blue colors in the polychromy of seventeenth-century Latvian churches, two pigments were always present: indigo and smalt. Natural ultramarine has been found in very few cases.

Details in the decoration of the Nurmuizha church are executed using a water-gilding technique. It is impossible to determine if a varnish or glaze is present, as the next gilding layer is applied in an oil-based mordant technique that fully blends with the first gilded layer.

The decorative wood carvings of the Burtnieki church are silvered and in some places covered with colored glazes.

Different hands are present in both churches, as during the seventeenth century in Latvia there was a continuous migration of craftspersons. A gilder-painter could have been called from any workshop, especially in rural areas, introducing that workshop's typical techniques and materials. It is not suggested that the described methods were the most common in Latvia. Any concrete conclusions can only be made after further investigations in Latvia, and after a comparison with methods used in other parts in Europe.

Acknowledgments

The authors are grateful to polychrome wooden sculpture restorers S. Rugevica and I. Pukse for the samples and for their help with the work. Thanks are due to M. Harris for editing the manuscript.

Notes

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Abstract

The shift in the nineteenth century from a tradition of artist-prepared materials to an industry of mass-produced commercial products greatly endangered the artistic community through the widespread distribution of products of inferior quality and unstable properties. For over fifty years, the British Pre-Raphaelite painter William Holman Hunt waged a campaign for the reform of the manufacture of artists' materials and the rights of the artist as a consumer to expect materials of consistent quality and uniformity. The re-evaluation of the Pre-Raphaelite technique, in conjunction with an exploration of Hunt's advocacy on behalf of artist-consumers, places in perspective his focus on artistic traditions at a crucial transition time in the history of materials and techniques.



Figure 1. William Holman Hunt in his studio, painting the St. Paul's version of *The Light of the World*, ca. 1900.

William Holman Hunt and the “Pre-Raphaelite Technique”

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Introduction

The late-eighteenth and early nineteenth centuries in British painting constitute a period noted for the rise of a major school of national painting, dominated by masters such as Sir Joshua Reynolds, Thomas Gainsborough, and J. M. W. Turner, who engaged in technical experiments of dubious value. Their reliance on gelled mediums, bituminous paints, and fugitive pigments, respectively, has left a body of work disfigured by sunken patches, wide *crackure*, and faded color. In search of shortcuts to achieve the luminous glow of the old masters, they produced, instead, paintings whose technical inadequacies were known and seen by the generation that followed.

This next generation of painters included the Pre-Raphaelite Brotherhood, formed in 1848 in radical opposition to the training and taste imposed on British art by the Royal Academy. Hunt was a founding brother, and the only one of the group to maintain a lifelong adherence to their principles of fidelity to nature minutely observed, boldness in color and lighting, emulation of early Italian painting, and depiction of contemporary or literary subject matter. Yet the rebellion was short-lived, and the Pre-Raphaelites rapidly became the leading painters of their day, with Hunt as one of the most popular.

By the 1870s Hunt's position was assured as the celebrated painter of such Victorian icons as *The Light of the World*, *The Awakening Conscience*, and *The Finding of the Saviour in the Temple* (Figs. 1, 2, 3). Periods spent in the Middle East seeking Biblical authenticity alternated with spells in pleasant, well-equipped London studios where, liberated from hand-to-mouth struggle, he was free to contemplate other aspects of art as a career (Figs. 4, 5). The stability and longevity of his paintings were of primary concern to Hunt, who observed not only the technical inadequacies of the preceding generation, but also the poor aging qualities of the artworks of his contemporaries.

Nineteenth-century commercial artists' materials

Hunt was among the first artists to note the increasingly poor quality of the artists' materials for sale in the mid-nineteenth century, and the most vociferous in calling attention to their faults and advocating their improvement. From the platform of leading painter of his day, he set out on a crusade to reform the manufacture of artists' materials, to impose standards of quality and workmanship, and to ensure access to consistently reliable products from colormen informed of and interested in the durability of the goods they were selling.

The market for artists' materials in the early and mid-nineteenth century had changed overwhelmingly with the advent of industrial production and mass marketing, and the rapid introduction and adaptation of newly developed materials whose aging properties were unknown. Prior to the nineteenth century, artists had used materials prepared for them in their own studios or by local artisans who followed the exacting standards of their clients, allowing the artist to determine the materials used and methods of preparation. With the rise of the commercial colorman in an age of burgeoning capitalism, a middleman was introduced between the manufacturer and the consumer of



Figure 2. William Holman Hunt sculpting a model of Christ's head to aid him in the painting of *The Light of the World*, ca. 1900.



Figure 3. William Holman Hunt, *The Finding of the Saviour in the Temple*, 1854–1860. Courtesy of the Birmingham Museums and Art Gallery, Birmingham, England.



Figure 4. John Ballantyne, *William Holman Hunt in his Studio Working on a Version of "The Finding of the Saviour in the Temple."* Courtesy of the National Portrait Gallery, London.

the product, a salesman motivated by the need for profit and immediate short-term customer satisfaction rather than long-term stability.

The evolution of the art market also brought with it an expansion of materials available for sale, aided by advances in scientific fields that greatly expanded the range of available pigments and dyestuffs. The artist's palette roughly doubled in the nineteenth century, each decade bringing new colors, starting with cobalt blue and lemon yellow. In the early part of the century, iodine scarlet, chrome yellow, and emerald green were introduced; and, in the 1820s, synthetic ultramarine became available. Zinc oxide (Chinese white) and viridian came in the 1830s, and cadmium yellow and orange followed in the 1840s. The 1850s brought the aniline dyes, brilliantly colored and wildly impermanent coal-tar derivatives. The 1860s saw the dawn of aureolin yellow, chromium oxide green, synthetic alizarin, manganese violet, cerulean blue, and so on (1). The colors produced by these new pigments were often dazzling, but also alarmingly unstable.

The evolution of artistic practices paralleled that of artists' materials, spurred by recent technological advances. The proliferation of the hobby of watercolor painting among fashionable English ladies and gentlemen dates directly from the invention of watercolor paints in handy dry-cake form by Reeves in 1766. The explosion of thick impasto and sculpted paint at mid-century follows the introduction of the flexible palette knife and the metal-ferruled flat brush. Perhaps the greatest revolution came in the 1840s in the form of premixed oil colors in collapsible tin tubes (2). Prior to this, outdoor painting was hampered by the need to transport messy, runny oil paints in animal bladders, which were both fragile and awkward to carry (Fig. 6). John Ruskin may have had good reason to call for the direct study of nature by artists, but the painter could not be freed from his studio until the studio could be brought outside with him.

Commercial tube paints required uniform consistency and pleasing handling properties, not to mention a good shelf-life, resulting in the introduction of all manner of fillers to the basic oil paint. Along with the pigment and binder were added a host of driers, stearates, waxes, petroleum jelly, preservatives, and extenders, added at best to improve handling, tone, and gloss and at worst merely to bring down the wholesale price of the product by reducing the amount of actual pigment used. With no regulatory authorities to ensure purity, no concept of consumers rights, and indeed little awareness of the detractions of mass production, the quality of artists' materials plummeted.

Simultaneously, a lust for profit led to the substitution of cheaper materials for pure pigments throughout the art market. Often, the colors named on labels were approximate descriptions, not guarantees, of the paint color. So widespread was this adulteration that in 1886 H. C. Standage published a popular handbook called *The Artists' Manual of Pigments*, which rated each pigment by artistic qualities, conditions of permanency and nonpermanency, and general adulterations, as well as providing general remarks and results from tests for purity and the nature of adulterants (3). For instance, Standage warned of false ceruleans made from the following: artificial ultramarine and Naples yellow; cheap Naples yellows bulked out with yellow ochres; yellow ochres adulterated with china and china clay; turmeric, Indian yellow, and aniline dyes, and so on; the chain of adulteration seemingly endless. Expensive madder lakes, he wrote, "are often adulterated with brick dust, red ochre, red sand, clay, mahogany sawdust, log wood, sandal and Japan wood, and bran; whilst the French madders have gum, sugar, salts, and other soluble bodies, as likewise lac, cochineal, and carthamus or safflower" (4). Corruption extended to drying oils and varnishes as well as pigments, and to raw as well as processed materials.

This is the dragon Hunt set out to slay, and the crusade spanned the last fifty years of his life, although widespread reforms were not seen until our own century. He began to write articles and to lecture in public. He corresponded

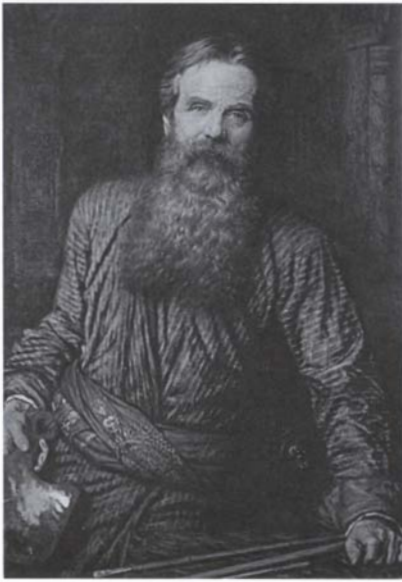


Figure 5. William Holman Hunt, Self-Portrait, 1875. Courtesy of the Uffizi Gallery, Florence, Italy. Note the length of the brushes on the table. The tunic is the same striped garment used in *The Finding of the Saviour in the Temple*.

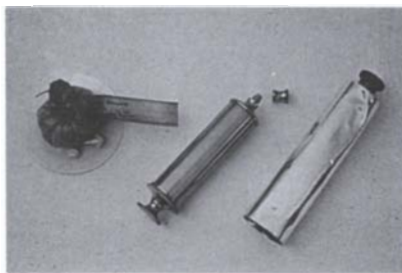


Figure 6. Nineteenth-century containers for oil paints (animal bladder with ivory tacks, piston tube, and collapsible metal tube). Courtesy of the Forbes Collection, Harvard University Art Museums.

with colormen and hired scientists to analyze paint samples from various suppliers. He badgered the Royal Academy into appointing their first professor of chemistry to research and teach materials science. He formed an artists' cooperative to secure hand-ground pigments and pure materials. He monitored the condition of his own paintings, attentive to the conditions of their display and handling. He made test panels and stored them in his studio ten, fifteen, and twenty years to observe the effects of aging. With ever-increasing obsession, he investigated material permanence, compatibility, and composition. Like a true conservator, he forsook the artwork for the artmaking, producing fewer paintings over longer intervals in a painstakingly slow technique.

Hunt's passions flared in the mid-1870s with the realization that Roberson's orange vermilion, a favorite commercial tube paint, was being adulterated with red lead, and thus blackening on the canvas. In frustration, Hunt wrote to his friend and fellow artist, John Lucas Tupper (5):

It seems as tho [sic] I were struggling against Fate. Every day sometimes including Sundays I have been toiling every hour, and just as I have got my task nearly completed the whole thing has fallen into disorder again for at least five or six times and I have had to begin again. At last I have found out what has been the cause of this: Roberson's tube of Orange Vermilion, which I used without suspicion because 25 years ago they sold this color absolutely pure, is adulterated with 10 percent of villainy, the greater part lead, which has blackened so rapidly that when it had got dry enough for the final glazings the flesh had got to such a color [sic] that I nearly went crazy . . . I have had the color analysed and at the same time have taken the opportunity to have others investigated and find that the fraudulent habit is exercised in many other cases. What is to me more discouraging than this is that many artists I have spoken to about [it] are quite satisfied to go on dealing in these spurious colors saying "Oh, they will last my time," and "I never found my pictures change" and with base humility "they," the colors, "are good enough for my work." Leighton, when I proposed a little co-operative society for importing and grinding pure colors said, "And what's poor Roberson to do?"

The culmination came on Friday, 23 April 1880, when Hunt addressed the members of the Royal Society of Arts on the subject, "The Present System of Obtaining Materials in Use by Artist Painters, as Compared with that of the Old Masters." At a conservative estimate, the talk lasted at least two-and-a-half hours. Concerned as much with the decline in knowledge of artists' techniques as well as materials, Hunt observed, "In the old days the secrets were the artist's; now he is the first to be kept in ignorance of what he is using" (6). Eloquently he informed his audience (7):

I feel called upon to avow that I regard the artists' colourmen of London as gentlemen of intelligence, of character, and great enterprise, to which qualities we are much indebted for the comparatively safe positions we enjoy; for indeed, at the worst, it must be recognised that we might have gone further astray. It is needful, however, that we should be not only in good hands, but we should give strong proof that we can distinguish between that which is faulty and that which is perfect; and it is the want of discriminating power in the painter which produces all the indifference on the part of the preparer to the permanent character of the materials he supplies. The painter has really not the power to trace the causes of defects. The colourman naturally judges of the character of the materials he vends by the condition they are in while under his own eye. To him, the evils revealing themselves in the work which has passed through his shop do not exist if he never sees them; and if he hears of them only, as evils untraceable in their cause which have occurred to one of his customers (who may, sometimes, have obtained materials elsewhere), his sense of responsibility is quieted, when he has received the assurance of his men in the workshop that the usual rules, which have hitherto resulted in work of a kind not eliciting

complaints, have been strictly adhered to. The workmen, too, in these shops are not permanent, and there is virtually no responsibility for any one preparation. In most cases the complaint is never made, for the evil may be a very serious one, and yet it may not manifest itself before the death of the artist.

In conclusion, he stated, “The cure that we have to seek is one it is possible to define compactly. It is to establish a means of transmitting the practical wisdom of one generation of painters to another” (8).

With striking prescience, he addressed the need “to found a society for looking after the material interests of painting . . . composed of important members of the profession of painting . . . [joined by] gentlemen of reputation in chemical science.” This society would form “a library . . . of all works of literature which exist on the subject of artistic practices . . . , establish a workshop for the preparation of materials . . . , arrange for the importing of colours from abroad for collecting specimens of experiments. An important aspect of the society will be to cultivate the opportunities of obtaining further samples of every variety of colours existing in the far East, of proving these, and putting them on record in our museum for all generations to see.” A technical school would be established, and artists trained, “that thus we should be the inheritors, not only of our immediate predecessors, but the heirs of all the ages, and that, though our pretensions would not be ostentatious in our humble way, we might be proud that we should be repeating the chosen tasks of the gods, the directing of inert matter to a spiritual end” (9).

The Pre-Raphaelite technique

Fully aware of the frailty of the materials of painting, Hunt became a master technician. Most of his paintings have remained well preserved, retaining the exceptional brilliancy of color which he strove so hard to achieve via successive layering of minute strokes of transparent and semi-transparent paint. He chose quality linen canvas stretched on paneled stretcher supports as “protection against accidental injuries, such as a push from a corner of a picture frame in the confusion which precedes and follows exhibitions, a kind of injury which, if not visible at the time, may show years afterwards in starred cracks in the hard paint” (10).

With some notable exceptions (such as the Liverpool *Triumph of the Innocents*, painted on handkerchief linen from an Arab bazaar because the artist was too impatient to await a delayed shipment of supplies from England), many of Hunt’s paintings remain unlined today and on their original stretchers, in the same gilt frames he designed for them. On other occasions, he had the paintings lined as a prophylactic measure, either during execution or shortly after completion (11).

Hunt chose his medium and surface coating with the same view to permanency as his pigments and support. Instead of the popular megilp, a gelled preparation of linseed oil and mastic varnish much used and abused by nineteenth-century British painters, Hunt used amber colors, smooth-flowing tube paints with pigments bound in a drying oil and copal resin. For once, Hunt diverged from sound technique, failing to foresee the embrittling effect to the paint layer over time from the addition of copal to the medium, along with the eventual yellowing of his colors due to the oxidation of the varnish component. With the best of intentions, he defended his choice of medium, noting that “amber varnish . . . protects the colours very perfectly, but has two slight disadvantages, as it lessens the brilliance of the white by the richness of the yellow tone in the varnish, and permits each touch to spread, though very slightly. Both these difficulties, however, occur immediately and may be calculated for” (12).

In spite of his profound interest in stability of materials and techniques, if Hunt is remembered at all today as a technical innovator, it is as the author of the Pre-Raphaelite technique, a technique actually attempted by very few



Figure 7. William Holman Hunt, *Valentine Rescuing Sylvia from Proteus* (Two Gentlemen of Verona), 1851. Courtesy of the Birmingham Museums and Art Gallery, Birmingham, England. This is the painting Hunt was working on when he described the wet-ground technique in his autobiography (I, 276): "The heads of Valentine and of Proteus, the hands of these figures, and the brighter costumes in the same painting had been executed in this way. . . . In the country we had used it, so far, mainly for blossoms of flowers, for which it was singularly valuable." Paint daubs of various mixtures of red are visible on the spandrels.

Pre-Raphaelite painters and never to any great extent. The myth of the Pre-Raphaelite technique arose from a single paragraph in Hunt's 1,000-page, two-volume autobiography. Citing as an example the painting *Valentine Rescuing Sylvia from Proteus* (Fig. 7), Hunt stated that he would (13):

Select a prepared ground, originally for its brightness, and renovate it, if necessary, with fresh white when first it comes into the studio, white to be mixed with a very little amber or copal varnish. Let this last coat become of a thoroughly stone-like hardness. Upon this surface complete with exactness the outline of the part in hand. On the morning for the painting, with fresh white (from which all superfluous oil has been extracted by means of absorbent paper, and to which a small drop of varnish has been added) spread a further coat very evenly with a palette knife over the part for the day's work, of such consistency that the drawing should faintly show through. In some cases the thickened white may be applied to the forms needing brilliancy with a brush, by the aid of rectified spirits. Over this wet ground, the colour (transparent and semi-transparent) should be laid with light sable brushes, and the touches must be made so tenderly that the ground below shall not be worked up, yet so far enticed to blend with the superimposed tints as to correct the qualities of thinness and staininess [sic], which over a dry ground transparent colours used would inevitably exhibit. Painting of this kind cannot be retouched except with an entire loss of luminosity.

In spite of the attention given to this quotation, however, it is rarely pointed out that Hunt describes this as a technique with which he experimented at one point in his career, used for specific design areas rather than entire canvases and not as a wholesale working method, as has been interpreted. Indeed, until the appearance of the autobiography in 1905, Hunt appears to repudiate his early experimental technique. It remains unmentioned in his first version of his memoirs, nor does it crop up in the frequent handwritten inscriptions in which he recorded details of technique on bare sections of canvas or support (14) (Fig. 8). Hunt dismisses its relevance to his career in an article on his painting technique that appeared in the magazine *Portfolio* in 1875, stating that he used wet grounds only from 1850 to 1854 to capture the effects of sunlight (15). While these five early years are viewed today as Hunt's period of greatest productivity and success, to his contemporaries his highest achievements came later in a career that spanned seven decades (16).

The sudden prominence accorded to the technique in 1905, may be due not to Hunt himself, but to his wife, Edith, seeking to enhance his reputation through the implication of technical innovation. Suffering from glaucoma, Hunt dictated much of his memoir to Edith who, according to their granddaughter, among others, took liberties with the text, "deleting passages . . . she considered *unsuitable* for posterity" (author's emphasis) (17). Edith's urge to improve went so far as taking advantage of her husband's blindness to have a studio assistant repaint Hunt's portrait of her, secretly slimming her waist and reddening her lips (18). It may well have been at her suggestion that the wet-ground technique, after fifty years of oblivion, abruptly became of importance in her husband's career, serving as one more opportunity to assert his innovation, skill, and pivotal role in the movement he had helped to shape.

Along with the disproportionate attention given to the Pre-Raphaelite technique comes a misunderstanding of the technique itself, due to a fundamental misreading of the word "ground." In Hunt's writings, the term often refers to an imprimatura, or underpaint, layer, rather than the intermediary priming that prepares a solid or fabric support to receive paint. In his diary, for example, Hunt refers to "lay[ing] a new ground for the left shoulder, which I do of white, cobalt green, and cadmium" (19). Further investigation confirms that Hunt's "wet ground" was actually a layer of paint, the "fresh white" of his writings referring to flake white oil paint, as he indicated in a letter of 1878 (20):



Figure 8. Infrared reflectograph of the handwritten notation under the paint layer in the upper right corner of *The Miracle of the Sacred Fire*, Church of the Holy Sepulchre at Jerusalem, at the Harvard University Art Museums. Inscriptions such as this one are frequently found in paintings by Hunt, either on the reverse of the supports, on bare spandrels, or underneath the paint layers. Image provided by the author.

I am obliged to wait long for the drying of the paint I put on to form a fresh ground, and while patience is being exercised as a necessity it seems but a little virtuous to summon hope to help me over the completing of the parts where the ground has finally become workably [sic] even and dry.

Indeed, Hunt complains here that the underpaint layer is wet, rather than seeking to exploit its freshness as part of his technique.

This reevaluation of the Pre-Raphaelite technique is consistent with the results of analyses carried out on cross sections taken from various paintings by Hunt, which indicate the blending of paint layers wet-into-wet, a common technique throughout the history of painting, rather than the swirling of paint layers into wet primings (21). This clarification not only places Hunt's achievements in a far more plausible technical frame, but also emphasizes, as he did throughout his career, his connection with and indebtedness to the

paintings techniques of the past masters, rather than the faddish disregard for tradition prevalent among his contemporaries.

Conclusion

In seeking reform, Hunt sought not to stop the wheels of progress but to channel them. His advocacy for the rights of the consumers in a time of rampant laissez-faire capitalism had ramifications throughout his century and our own, contributing directly to the enactment of regulations governing the safety of commercial goods and legislation regarding truth in advertising. His sophisticated understanding of the science of painting, in spite of limited formal schooling, and the impact of environment in the preservation of art place him as a key figure in the development in the professions of art conservation and museology. His understanding of historic painting techniques, well advanced for his day as well as our own, generated a revival of the craft of painting after a generation notorious for technical inadequacies. Too often he has been dismissed by art historians as a minor painter of deeply tasteless religious scenes. His contribution to nineteenth-century British painting and to the current stability of commercial artists' materials must not be underestimated.

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Notes

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4. Standage, op. cit., 53–54.
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6. Hunt, W. H. 1880. The Present System of Obtaining Materials In Use By Artist Painters, As Compared With That of the Old Masters. *Journal of the Society of Arts* 28 (23 April 1880), 492.
7. Hunt, op. cit, 492.
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9. Ibid.
10. Hamerton, P. G. 1875. Technical Notes—W. Holman Hunt, an interview with the artist. *The Portfolio: An Artistic Periodical* VI (1):45.
11. Original paint extends over onto the tacking margins of the lining canvas and the gummed tape edging the lining of the Birmingham *Finding of the Saviour in the Temple*. Conservation files, Birmingham Museums and Art Gallery.
12. Hamerton, op. cit., 45.

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14. Hunt, W. H. 1886. The Pre-Raphaelite Brotherhood: A fight for art. *The Contemporary Review* 49 (April):471–88, (May):737–50, (June):820–33.
15. Hamerton, op. cit., 46.
16. Of course, the Pre-Raphaelite Brotherhood in its strictest sense only endured from 1848 to 1854, so a purist might claim it as a Pre-Raphaelite technique, although all the Brothers quickly returned to traditional painting techniques, and only Hunt and John Everett Millais had ever developed it to any great extent.
17. Holman-Hunt, D. 1969. *My Grandfather, His Wives and Loves*. London: Hamish Hamilton, 18.
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21. Consistent results have been achieved in cross-section analysis carried out by the author, and by conservators at the Tate Gallery and University College, London, among others.

Abstract

The production of a painting in early nineteenth-century France followed a clearly defined sequence of steps. After drawings had been made, the composition was outlined on the prepared canvas and the modeling was indicated, often with a reddish-brown “sauce.” Local color, light, and shade were laid in; this sketch was elaborated using a full range of tones laid out individually on the *ébauche* (palette). The final stage of painting refined this process further. This is demonstrated in Paul Delaroche’s *The Execution of Lady Jane Grey* (1833). A pupil of Watelet and Gros, Delaroche received much popular acclaim during the 1830s, and a number of eminent painters passed through his studio. Thus he occupies a central position in the history of academic painting.

Paul Delaroche: A Case Study of Academic Painting

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Introduction

The July Monarchy of Louis Philippe, who came to the throne in 1830, was a period of technological advance and increasing industrialization, marked by the rise of a wealthy and influential middle class. It was distinguished by its adherence to the philosophy of eclecticism, not only in politics, but also in the realm of the arts. Official art followed a middle course between the two dominant trends, Classicism and Romanticism, showing the careful composition, drawing, and modeling of the former and an interest in the subject matter and emotional content of the latter. The painting of the *juste milieu* could justly be described as the art of the bourgeoisie. Paul Delaroche, who rose to prominence at this time, was one of its most popular and successful exponents (1, 2).

Born in 1797, the son of an art dealer, Delaroche (christened Hippolyte) entered the studio of Antoine-Jean Gros, a disciple of David, after early training with the landscape painter Louis-Étienne Watelet and with Constant Desbordes. The recipient of many honors, royal patronage, and several official commissions, Delaroche achieved early Salon success. In 1833, he inherited Gros’s studio and became a professor at the École des Beaux-Arts (3, 4, 5, 6). His atelier was perhaps the busiest and most effective of the period; his pupils included Gérôme, Daubigny, Millet, Monticelli, and Thomas Couture, himself the master of Edouard Manet (7).

The Execution of Lady Jane Grey

Delaroche’s *The Execution of Lady Jane Grey*, finished in 1833, achieved considerable success at the Salon exhibition of 1834. The subject, drawn from English Tudor history and depicted with ostensible accuracy, appealed to popular taste. The scene depicted—the moment immediately before the beheading—was that of the greatest dramatic tension; it also touched the sensibilities of the public without disgusting them. As Etienne-Jean Délecluze wrote, “The spectator can contemplate the axe . . . without horror” (8) (Plate 33). The blindfolded Lady Jane fumbles for the block; a figure who is probably intended to be Sir John Brydges, the Lieutenant of the Tower of London, gently guides her hand. On the left, a despairing lady-in-waiting turns her face towards the massive column; the other lady-in-waiting, her mistress’s discarded dress across her lap, has fainted. The impassive executioner stands on the right. Delaroche’s historical sources for the painting included the *Martyrologue des Protestans* of 1588, quoted in the Salon catalogue (9). There were a number of other publications, as well as the works of other painters, upon which he could have drawn, including Hans Holbein the Younger’s painting of Anne of Cleves, which was at the Louvre (10, 11). Delaroche undertook exhaustive research before any painting project (12).

Adored by the crowds, the painting was praised and condemned in almost equal measure by the critics. The criticism that Delaroche’s treatment was theatrical rather than dramatic, voiced by Gustave Planche among others, is interesting as it may reflect an aspect of the artist’s practice: Delaroche used small model rooms, within which he arranged wax figures to assist in the composition of his paintings (13, 14). According to Edward Armitage, a for-

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Figure 1. The Execution of Lady Jane Grey, after cleaning and before restoration.

mer student, the use of similar “boxes” to study the fall of light upon small draped models was not uncommon (15). It is fair comment that the scene depicted takes place uncomfortably close to the picture plane within a stage-like space.

The 1834 Salon catalogue states that the painting was owned by Prince Anatole Demidoff, who paid 8,000 francs for it. It remained in private ownership until it was bequeathed to the National Gallery by the second Lord Cheylesmore in 1902 (16). In 1928 it suffered flood damage while at the Tate Gallery and was later described as destroyed (17). In 1973 it returned to the National Gallery, where examination showed that the condition of the painting was not as bad as had been feared, consisting principally of tears in the canvas (the largest tear through the executioner’s feet) and associated paint losses. Figure 1 shows the picture before restoration after it had been repaired, double lined with wax resin, and cleaned (1974–1975). Evidently its construction must have been relatively sound, and this was confirmed by its recent technical examination (18).

Method and materials of painting

The highly finished Salon painting or Academic picture was the result of a well-established procedure; the artist would make preliminary studies, an *esquisse* (a sketch of the intended composition), and detailed drawings before transferring the design to canvas and beginning to paint (19, 20, 21, 22). These



Figure 2. Paul Delaroche, Study for The Execution of Lady Jane Grey, ca. 1833. Watercolor and body color over pencil, with varnish, 18.4 × 14.3 cm. University of Manchester, Whitworth Art Gallery.

steps may be observed in *The Execution of Lady Jane Grey* and other works by Paul Delaroche. It must be remembered that the artist may have been assisted by students at certain stages in the production of a painting of this size, even though there is no obvious indication of this here (23).

Compositional sketches for several of Delaroche's paintings survive; *Joan of Arc in Prison* (London, Wallace Collection), for example, was painted as the sketch for *Joan of Arc . . . Interrogated in Prison by the Cardinal of Winchester* (1824, Rouen, Musée des Beaux-Arts) (24, 25). Most are smaller than the final versions and all are more freely painted. Delaroche felt strongly that a preliminary sketch embodied the artist's imaginative process and inspiration (26). The only known compositional study for *The Execution of Lady Jane Grey* is a small watercolor in the Whitworth Art Gallery, Manchester (Fig. 2). Here, Delaroche sets the figures within a Romanesque interior and only the executioner, who stands in profile holding a sword, is significantly different from the large final version (27). Many minor alterations can be attributed to scaling up and improving the composition: modifying the background arcade and staircase, for example, and simplifying the costumes. The striking transformation is in the color, which is so resonant and warm in the finished version in contrast to the cooler and less coherent tonalities of the watercolor. In the sketch, the executioner is dressed in dull green and red; the attendant facing the column is portrayed in deep blue, rather than rich dark purple. In the sketch, light plays evenly across the room; in the painting, it is more concentrated on the figures, although the pattern of light fall is similar. The squat, oddly appealing figures of the tiny watercolor have been transformed into an elegant, theatrical "tableau."

The next step was to make drawings for the composition's elements. Much importance was traditionally attached to drawing, and Delaroche produced hundreds of drawings during his career (28). Several must have been made for *The Execution of Lady Jane Grey*. Two studies for it on paper certainly survive, one in the Musée du Louvre in Paris, the other in the British Museum in London (Fig. 3) (29). The Louvre sheet shows the figure of the executioner on the left, squared up for transfer: It is very close to that in the



Figure 3. The Execution of Lady Jane Grey. Pencil drawing for the central group, 18 × 16.5 cm. London, British Museum (formerly National Gallery, London).

finished painting. The two other figures on the sheet are studies for Lady Jane's ladies-in-waiting; neither has been squared up. That for the standing figure has been used with little modification. The other figure in the Louvre drawing appears to kneel and pray facing the central group; this composition was not used in the final painting, in which the slumped position of the attendant is very much as it is in the watercolor study—to greater dramatic effect. The British Museum drawing shows Lady Jane and Sir John Brydges; it has been used with little modification. There are small differences in details of costume between the drawings used and the finished painting.

Apart from his use of draped figures in room sets, discussed above, the artist was in the habit of making wax or plaster models of elements of the composition when he felt there was a problem to be solved; a plaster model was made of the two princes, for example, in *The Children of Edward IV* (1830, Musée du Louvre) (30). This appears not to have been necessary for the *Lady Jane Grey*.

The chosen drawn versions of the figures would then have been transferred to the prepared canvas. The canvas for a painting of this size would have been stretched to order, apparently from a single piece of medium-weight linen; the largest stock canvas was a *toile de 120* (about 1.3 × 1.9 m) (31). The roll of canvas used was already primed with a ground of lead white in linseed oil. Over this first priming, Delaroche then had a second ground—also of lead white, but this time bound in walnut oil—applied to the stretched canvas.

Delaroche seems to have transferred designs for the single figures or groups individually; infrared reflectography has revealed “squaring-up” lines under the paint of Lady Jane's dress, her seated attendant, and in the area of the



Figure 4. Infrared reflectogram from Lady Jane Grey's skirt in *The Execution of Lady Jane Grey*.

block, but the scale of these various grids suggests that there is no single system of squaring across the entire picture surface. The infrared images show many changes in the underdrawing; lines drawn across Lady Jane's wrists suggest that her dress was to be long-sleeved, as in the watercolor sketch (Fig. 4). At the drawing stage, Delaroche also indicated such features as shadows in drapery folds, as seen in the standing woman's dress.

In many unfinished French paintings of this period it can be seen that the underdrawing has been strengthened with a translucent brownish wash, sometimes known as "sauce" (32, 33). In this case, no such material could be detected with certainty in any of the cross sections examined, and only the charcoal drawing was found; possibly a grayish wash, for example, was applied in the shadows of folds.

Subsequently the figures and background were laid in using brownish or grayish shades of paint, composed of lead white combined with a variety of tinting pigments (Cassel earth, ochres, and other natural earth pigments, as well as small quantities of cobalt blue, a red lake pigment and black). The tonality of this underpaint bears some relation to the color of the paint that was to be applied on top, thus the background and black garments are underpainted in shades of gray, while the underpaint of the flesh varies from a warm beige for the executioner to a grayish white for Lady Jane. The underpaint also indicates light and shade, by varying the proportion of ochres, black, and cobalt blue in the mixture, the color of the underpaint of Lady Jane's dress is changed from a pale beige in areas of highlight to a dark brown in the deepest shadow. Occasionally, the underpaint is similar in color to the intended local color; for the cushion it is a translucent green consisting of black, verdigris, Prussian blue, yellow ochre, and perhaps a yellow lake.

At this point the painting would have had an appearance not unlike a *grisaille* version of the final composition, an element of Delaroche's practice mentioned by Delaborde (34). Infrared reflectography has revealed many *pentimenti*, however, bearing out comments by students that Delaroche frequently reworked passages during painting (35). The executioner appears originally to have had a sash around his waist, for example, and the position of the pike behind the balustrade and the angle of the banisters have been altered. The underpaint for the executioner's tights is mauve-gray (composed of lead



Figure 5. Detail of Lady Jane Grey from *The Execution of Lady Jane Grey*.

white, red lake, and black), similar in color to that used in the watercolor sketch; the presence of a thin layer of black paint above it, darkening or obliterating it, suggests a change of mind. Above it is a much warmer version of the underpaint layer, containing more red lake pigment, followed by the desired red paint (Plate 34a).

This grisaille probably represents the *ébauche* stage of the painting (36). When it was dry, the local color was applied. Bouvier describes the use of a series of premixed, graduated middle tones applied side by side and then blended to give an smooth passage from light to dark across each part of the painting, for both the *ébauche* and the final paint layers (37). The simplicity and precision of the layer structure and the generally close relationship between the depth of tone in the grisaille and the *chiaroscuro* of the finished painting, as demonstrated in the painting of Lady Jane's dress, suggests that something approaching this may have been done (Fig. 5). Only one or two quite thin, even layers of paint may be present over the underpaint, with perhaps an additional glaze or highlight. Observation of the paint surface, however, and the occasional presence of extremely thin scumbles or glazes of paint (or simply a greater concentration of paint medium) at the top of a paint layer reveal the careful blending of tones. One paint layer frequently appears to have been applied over another while the layer below was still fresh, enabling one mid-tone to be merged into the next. Plate 34b shows a cross section of paint from the shadow of a fold in Lady Jane's dress. The grayish paint of the shadow, consisting of lead white with a little cobalt blue and Cassel earth, merges with the creamier paint of the layer below so com-

pletely that it is difficult to distinguish between them. The lowest paint layer (above the grayish wash of the drawing and the white ground) is the dark undermodeling of the *ébauche*, containing Cassel earth, charcoal, and cobalt blue. This is probably sufficiently dark in color to contribute to the observed *chiaroscuro* of the dress (a similar mixture is used as a final glaze for the deepest shadows). The creamy mid-tone of the dress consists principally of lead white, with traces of yellow ochre, Cassel earth, and cobalt blue; the proportion of the tinting pigments is altered as one tone blends into the next, however. The blending process is also reflected in the presence of a number of paint layers in subtly different shades of cream in different parts of the dress. Only in the lightest highlights is lead white used almost pure, ground in walnut oil; even here, the presence of a trace of cobalt blue gives it coldness.

This general pattern of paint construction is repeated elsewhere in the painting. Passages of paint containing a pigment used more or less unmixed are very rare indeed, but in the red glazes supplying the purplish red of the brocade dress, on the lap of the seated lady-in-waiting in Figure 6c, and the shadows on the executioner's tights, a crimson lake pigment was used in this way. In both cases, the dyestuff present was that extracted from a cochineal insect, *Dactylopius coccus* Costa, on a substrate consisting largely of hydrated alumina. The brown paint of the brocade, containing yellow ochre with other iron oxides and black, contained ordinary linseed oil; the red glaze, however, contained heat pre-polymerized linseed oil and a little mastic resin (Plate 34c). This indicates the use of a varnish of the type recommended as a painting medium, perhaps the jellylike *vernis des Anglais* described by Mérimée as being particularly suitable for glazes because it could be brushed on so easily (38). The presence of a resin-containing medium is also suggested by the whitish fluorescence exhibited by the glaze layer in ultraviolet illumination under the microscope.

The paint used for the red of the executioner's tights is perhaps surprisingly complicated, as it contains two red lake pigments mixed with vermilion and lead white (Plate 34a). Examination under the microscope suggests that one is the cochineal lake used in the glaze; the other, less crimson in color, was not present in sufficient quantity for analysis, but its pronounced orange-pink fluorescence in ultraviolet illumination suggests that the dyestuff may have been extracted from madder root, the use of which was being developed in France at the time (39). Curiously, the same lake (mixed with black and cobalt blue) is used rather than the more crimson cochineal lake for the attendant's purple dress. Even the velvety black of Sir John Brydges' garment is a mixed color: it contains a subtle combination of black, Prussian blue, red lake, and a translucent yellow pigment (Plate 34d). This combination is similar to Edouard Manet's tinted darks in *Music in the Tuileries Gardens*, painted thirty years later (40). Quite marked brushwork is visible in the black garments of Sir John and the executioner; analysis shows that Delaroche used a varnish-type painting medium of similar composition to that used for the red glaze, which retained the texture of the brush strokes.

To summarize, Paul Delaroche painted a *grisaille* of his composition and then colored it in; the labor necessary to produce the finished painting was, however, considerable barely revealed on its bland surface. The painter's craftsmanship and understanding of materials cannot be denied; his reliance on lead white and ochres in particular and the absence of bitumen have resulted in a paint film in remarkably good condition, considering the recent history of the painting. The use of a varnish-type paint medium has often proved to be a recipe for disaster; in this case the paint shows few of the defects often caused by its use. Delaroche appears to have added only cobalt blue and synthetic ultramarine (and possibly an improved madder lake) to what could be described as a conventional eighteenth-century palette.

The production of the Salon painting was not the end of the story. Public awareness of successful Salon paintings was increased by means of reproductions in the press; several of Delaroche's paintings, including *Children of Edward*



Figure 6. Paul Delaroche, *The Execution of Lady Jane Grey*, ca. 1834. Canvas, 45.7 × 53.3 cm. Corporation of London, Guildhall Art Gallery.

IV, were reproduced by lithography. Artists were also able to keep their works in the public eye by means of high-quality engravings and Delaroche had an arrangement with the print publisher Adolphe Goupil to produce and publish engravings, after his paintings (41). For large paintings, including *Lady Jane Grey*, *The Children of Edward IV*, and *Joan of Arc*, he painted a reduced-scale copy from which the engraving could be made (42). In the case of *Lady Jane Grey*, it is possible that the painting now in the collection of the Guildhall Art Gallery, Corporation of London, is the reduced-scale copy (Fig. 6) (43). The engraving, by Mercurij, one of several engravers who engraved the painter's works for Goupil, was begun in 1834, but was only completed in 1857, the painter himself having died the previous year (44).

Acknowledgments

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Abstract

Turner's use of sketches on paper, his development of successful oil sketches into finished paintings, his preference for absorbent primings, and his modified oil media are described. His oil painting techniques circa 1800–1850 are illustrated by studies of several works. His use of megilps (varnish-modified oil media) is outlined, along with his use of newly available manufactured pigments, and is compared with analyses from other works painted by British artists 1775–1875, ranging from Reynolds to Whistler.

Painting Techniques and Materials of Turner and Other British Artists 1775–1875

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Introduction

This paper presents important aspects of J. M. W. Turner's technique, discussed before by the author in greater detail, by examining several paintings not previously described in this context (1, 2). Turner painted in oil for over fifty years (ca. 1798–1850), and it is interesting to compare his materials to those used in British paintings of the preceding and following twenty-five years (in the Tate Gallery collection, unless otherwise stated). Thus, this paper presents a comparison of the use of modified paint media and the adoption by various artists of new pigments produced between 1775 and 1875.

Turner's oil painting techniques, compared to others' techniques

Turner spent at least ten years as a watercolorist before he used oil as a paint medium, developing a range of techniques that he would utilize ever after in oil. In the earlier watercolors, transparent washes overlie the white paper except where Turner reserved highlights. The greens were made by mixing, overlaying, or physically mixing with his fingers, washes of brown and blue. There is very little underdrawing, and generally it is free rather than detailed. The mental image was transferred directly to the support. As Farington wrote, "Turner has no settled process but drives the colour about till he has expressed the ideas in his mind" (3). Turner produced over 20,000 pencil sketches and watercolors, now at the Tate Gallery, but few have a direct counterpart in oil. He hardly ever produced a detailed oil sketch, even for a commission, and when he sketched in oil he developed the best sketches into completed and exhibited works, rather than repainting them on a new canvas.

Turner seems to have tried nearly all materials and methods once. The following descriptions apply to many of his paintings, if not all. Once he began to work in both media (always independently), he utilized new application techniques and pigment in both media at about the same time. His early work in watercolor gave him an understanding of and liking for light-toned, absorbent surfaces, and honed his skills in the application of optical greens and blacks. Some eighteenth-century artists such as Wright of Derby (4) used white grounds to lend luminosity to their oil paintings, but many of Turner's immediate contemporaries were using thicker paint and warm-toned grounds up to 1820. Constable produced oil sketches upon mid-toned buff, red, or blue grounds, though his exhibited works do not show quite such a variety of grounds (5). After 1820, more British artists tended to use white grounds. Many commercially primed canvases are white during this time and up to the 1890s, when Sargent and Whistler used gray ones of varying tones in England (6). Turner used white primings for a fair proportion of his oils, both exhibited and unfinished, in the first decade of the nineteenth century; in later decades most of his supports had white grounds. In a fair number of the paintings examined, the primings consist of lead white in whole egg medium (7), most of the others being lead white in oil, not sized on the surface or between applications of priming, as had previously been usual. Absorbent surfaces gave the impetuous Turner a very rapid indication of the final color of the paint, and allowed him to develop the composition rapidly over fast-drying paint if it looked promising.



Figure 1. J. M. W. Turner, *Goring Mill and Church*, ca. 1806–1807. Oil sketch on canvas, 857 × 1162 mm. Courtesy of the Tate Gallery, London (N02704).

Some works were abandoned at this stage, for example *Goring Mill and Church* (ca. 1806–1807), in which the buildings were lightly drawn in pencil before washes were applied of thinned linseed oil paint in green and brown for grass, buildings, and cattle, and in highly thinned, pale blue paint to suggest the clouds (Fig. 1). Other abandoned oil paintings from this date and later have little or no pencil underdrawing. Turner used it mainly to outline buildings or ships, where accuracy mattered. By contrast, landscapes and trees were usually freely painted. In later years, Turner used increasingly brightly colored, thinned paint as a first lay-in, generally brown for the landscape and blue for the sky, leaving white priming in areas that would later be depicted as yellow sunlight. He glazed down the colors as he worked. Cross sections from most oils show thin transparent washes, overlaid by thin paint layers in the same colors, lightened with lead white. Some abandoned works have a patch of bright red or blue in the foreground, which Turner would have developed into something appropriate as the image evolved, perhaps a red buoy in the sea, or a brightly dressed figure in a landscape.

Turner's earliest oils look thickly and conventionally painted at first glance or when viewed through accumulated yellow varnish, but this is deceptive. *Dolbadern Castle, North Wales* is a good example (Fig. 2). Turner presented it to the Royal Academy, London, when he obtained full membership at the age of twenty-eight. Recent cleaning revealed thin glazes of Mars orange (i.e., strongly colored synthetic iron oxide) and localized scumbles of black, and Mars orange or red, with white in the landscape. The surface was, in fact, vulnerable and potentially sensitive to solvents. Clouds were applied with a thicker, creamy-looking paint that retained brush marks, small areas were then scumbled over with quite bright yellows or pinks, applied rather lean. Naples yellow, reddish brown ochres, a purplish ochre, and ivory black provided these highlights, while the sky itself was painted in ultramarine, lightened with lead white. Turner continued to use ultramarine for finishing skies throughout his life, having often done the initial lay-in with smalt, though not in this case. He used Prussian blue glazes and washes over thicker layers of brown ochres and umbers for the greener parts of the landscape and the stream. The fast-flowing water is indicated by small flecks of textured white paint. These may be lean strokes of paint applied in a pure oil medium. In other paintings, such areas were found to contain linseed oil but very rarely walnut oil, despite the fact that the latter was known to yellow less. It is much less likely that the

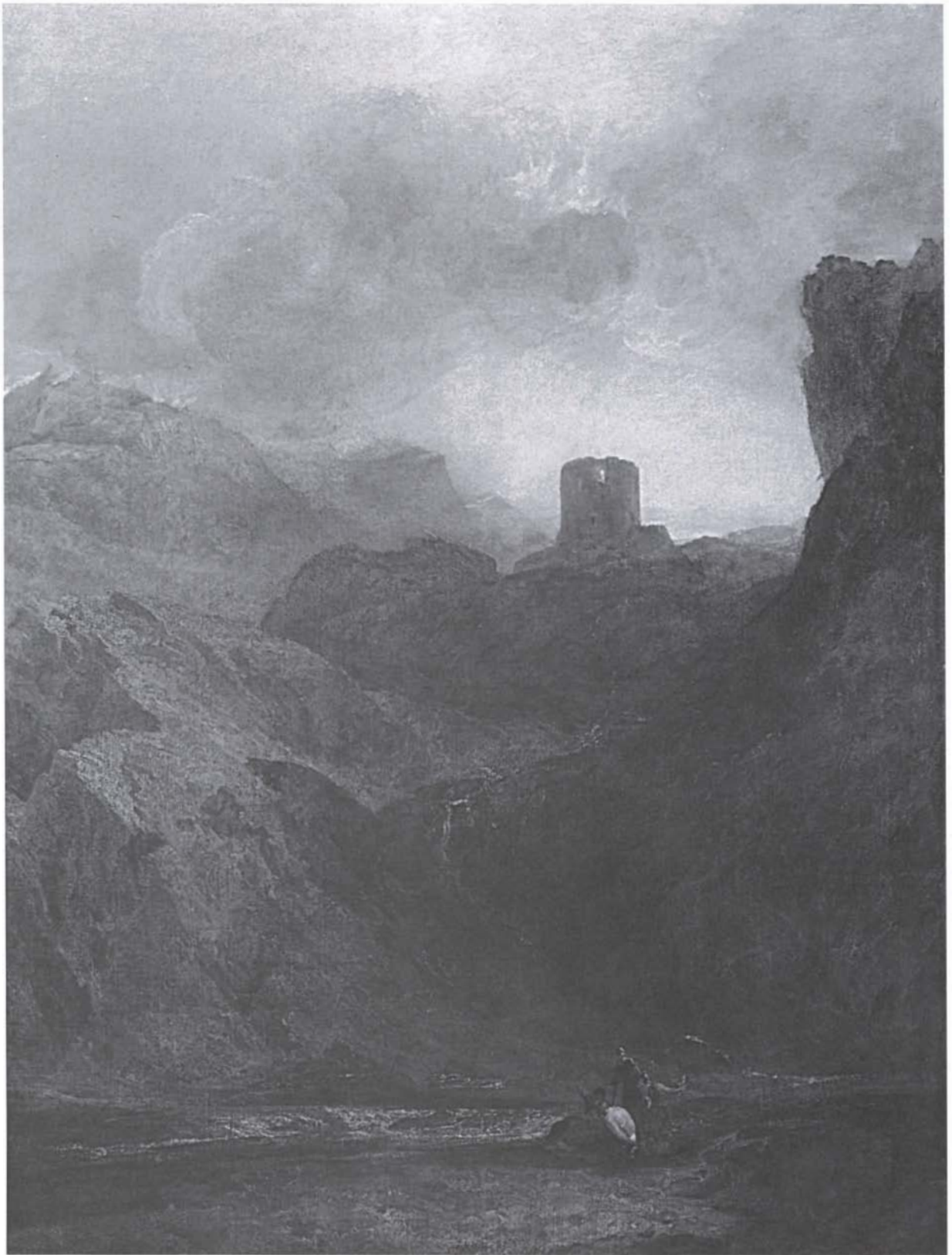


Figure 2. J. M. W. Turner, *Dolbadern Castle, North Wales*, 1802. Oil on canvas, 1190 × 889 mm. Courtesy of the Royal Academy of Arts, London.

textured clouds were painted in pure oil medium; they more resemble a megilp, a medium discussed in detail later.

Many of Turner's oils are disfigured by wide contraction cracks long associated with natural bitumen or asphaltum. The paint of *Dolbadern Castle* is free of such defects, possibly because the subject did not require the extreme contrasts between sunny and shaded landscape that Turner achieved so effec-

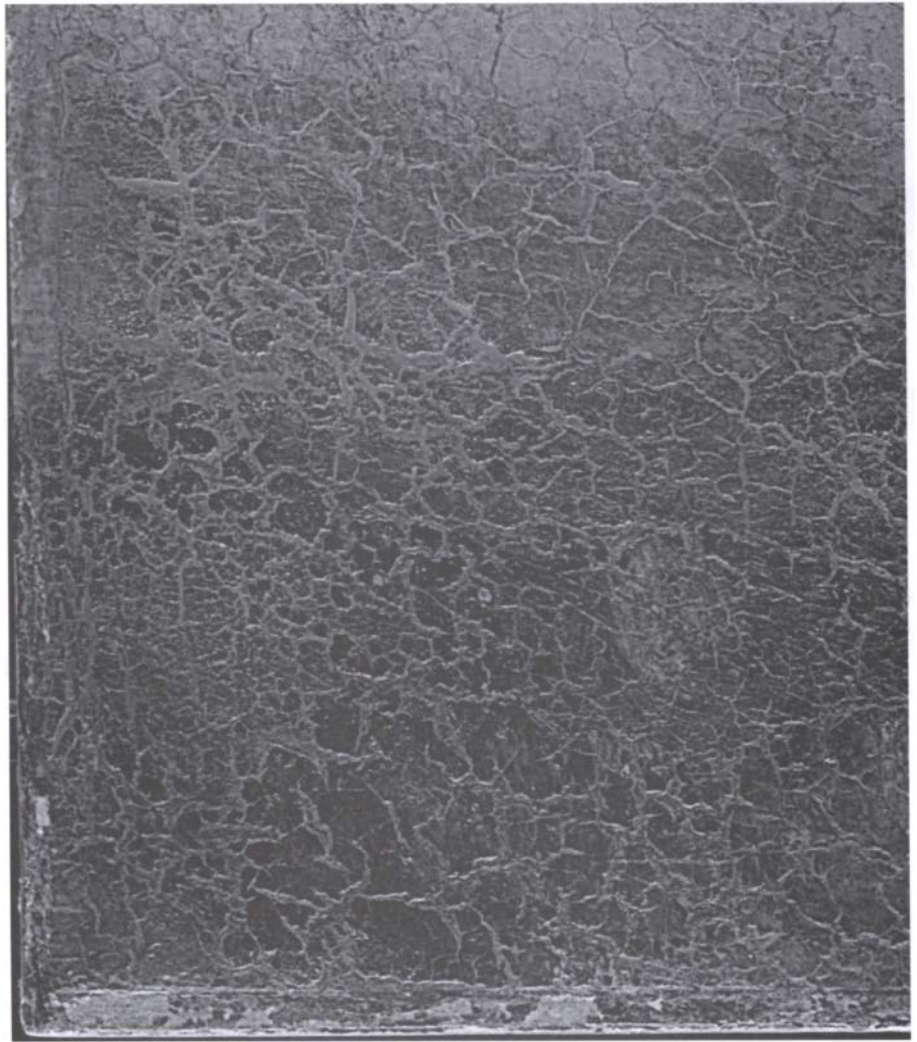


Figure 3. Detail of lower left, showing contraction cracks in bitumen-rich paint, from J. M. W. Turner's *The Hero of a Hundred Fights*, ca. 1800, reworked 1847. Oil on canvas, 908 × 1213. Courtesy of the Tate Gallery, London (N00551).

tively elsewhere through the use of bitumen, megilp, and resinous glazes. Bitumen has been detected in his Italian landscapes of 1820–1840 in particular, and appears at its worst when used as an underlayer for the foreground. In other works, Turner added to bitumen's poor drying characteristics by painting it directly over old damaged paint or by exposing canvas to extreme dampness and dripping water, so the support stressed the paint and caused cracking. It is not certain whether he ever used synthetic bitumen, a material severely criticized by his contemporaries, and reputed never to dry at all (8). Figure 3 shows a detail from Turner's *The Hero of a Hundred Fights* that has bitumen-rich paint applied over oil paint a few decades old, showing severe cracking typical of this artist's oeuvre. Figure 4 shows even more disfiguring cracking, attributed to synthetic bitumen, in a study of Editha's head for Hilton's *Editha and the Monks Searching for the Body of Harold*.

The full complexity of Turner's later paintings can be represented by *The Dawn of Christianity*, *The Flight into Egypt*, exhibited in 1841. Turner used a square canvas with a white, absorbent priming of lead white and oil, and planned the work for a non-square frame. He sketched in octagonal cut-offs in pencil, drew a circle with pencil and compasses, and then painted a more or less circular image. He prudently made use of the corners of the canvas to try out colors, and quite large brush loads of paint survive there, uncontaminated by later layers. Figure 5 shows the framed painting, and Plate 35 shows a detail of the lower right corner. The most textured paint, nearly free of pigment and by now honey colored, proved to be a megilp. The canvas is



Figure 4. Detail (showing cracks) from William Hilton the Younger's study of Editha's head for Editha and the Monks Searching for the Body of Harold, ca. 1834. Oil on canvas, 335 × 244 mm. Courtesy of the Tate Gallery, London (N00333).

unlined. The paint dribbling down the tacking margins at an angle suggests Turner used a sloping easel, probably the tripod type depicted in his watercolors. There are very few descriptions of Turner painting, but observation of the paintings and cross sections makes it clear that he thinned paint excessively, until it contracted into islands as it dried (visible in the foreground); at other times, he mixed paint in drying oil on the palette so rapidly as to leave recognizable blobs of the added oil. Almost certainly, Turner completed *The Dawn of Christianity* at the Royal Academy in the three days required of other artists of his era for retouching sunken areas or applying varnish. The sky paint was applied rather thickly with a palette knife, as was white impasto in the lower right. Both paints consisted of good quality lead white with few impurities. Turner sometimes modified the sky with opaque scumbles, but rarely glazed it, emphasizing the contrast between the sky and the highly glazed landscape in the foreground. The middle ground was painted rapidly



Figure 5. J. M. W. Turner's *The Dawn of Christianity, the Flight into Egypt*, exhibited 1841. Oil on canvas, 787 × 787 mm. Courtesy of Ulster Museum, Belfast, Northern Ireland.

with megilped paint, and hence has high impasto that did not slump as it dried. Turner may even have mixed the megilp into the oil paint on the canvas, rather than on the palette. Beeswax and spermaceti wax, added to oil and both found in this painting (9), yielded a more flowing medium used to good effect in the more distant trees, though the prominent tree on the right has a more strongly textured trunk painted with megilp. The very thin, later glazes that ran off the edges and soaked into the corners of the absorbent canvas would have soaked less into medium-rich paint. Turner used emerald green here (and quite frequently by this date) to provide a stronger contrast with chrome yellows and orange than that provided by an optical green. Curiously, green mixtures of opaque blues and yellows are virtually unknown in his paintings. The original varnish may have survived on this painting in the hollows of textured paint, where it has entrapped hogs' hairs, as in other Turner oils in which the varnish may be original. Little can be said conclu-

sively about the varnishes Turner used. He may have varnished later works only when they were sold.

Megilps compared to oil medium

There are numerous references in artists' manuals and critics' reviews to megilps, combinations of mastic varnish and drying oil that gelled on mixing, and could then be mixed into pure oil paint on the palette (10). Megilps (thixotropic medium modifiers) had excellent handling characteristics both for impasto and glazing, but a severe tendency to darken, and to cause cracking whenever varnish was applied. Such materials had been used and criticized at least since Reynolds' time. Recent studies have shown that megilps can be made successfully from linseed oil cooked with lead acetate or litharge, cooled, and later mixed with mastic spirit varnish (11). These megilps subsequently show different behavior on aging, and Turner's paint is somewhat closer to lead acetate megilp. Pure megilp samples from the corners of *The Dawn of Christianity* certainly contain lead and behave when heated like artificially aged lead acetate megilps made from nineteenth-century recipes. Megilped white paint from this painting and the considerably earlier *Dolbadern Castle* has rather a different chemical composition from pure drying oil (12), being more hydrolyzed and less oxidized, as though a drier were present from the beginning. Documentary evidence indicates that Turner used lead acetate in copious amounts.

Megilps are two-component materials whose properties vary significantly as the oil:resin proportion changes from 1:3 to 3:1. Film-forming capability, the tendency of the megilp to segregate afterwards, its tackiness, and its ability to absorb more or less dust than oil paint all depend on the exact proportions. Turner, who worked fast and furiously, and never even paused to grind his pigments finely, must have used a variety of formulations and proportions of megilp, albeit unconsciously. This has led to variations in degree of yellowing and solubility in Turner's paintings, and made them very sensitive to cleaning. Megilps, as well as paints with a startling variety of melting and softening points, have been found in numerous samples from Reynolds's later paintings of the 1780s. Reynolds's *The Death of Dido*, one of the "fancy pictures" wherein he is said to have used paint media that he never allowed his pupils to use, is particularly rich in megilplike layers and has some very striking surface defects. They arise when a modified oil layer is applied to fairly pure oil, whereupon microwrinkles form in the previously stable film, and the surface later exhibits a rough texture with drying cracks cutting in deeply.



Figure 6. Detail of Anna's veil, painted over clouds and sky, from Joshua Reynolds's *The Death of Dido*, ca. 1781. Oil on canvas, 1473 × 2407. Courtesy of The Royal Collection, Her Majesty the Queen.

Table 1. Dates of manufacture of inorganic pigments introduced 1775–1875, with the earliest instance of their use found to date in oil paintings at the Tate Gallery.

Pigment	First manufacture	Earliest date	Artist	Source
Prussian blue	early 18th c.	by mid-18th c.	various	
Marrad	mid or later 18th c.?	1755–1760	Reynolds	a
Mars yellow	mid or later 18th c.?	1781	Reynolds	a
Mars brown	mid or later 18th c.?	1781	Reynolds	
patent yellow	published ca.1775	1781?	Reynolds	a
Scheele's green	used 1775 published 1778	ca. 1806–1807	Turner	a b
cobalt green	pub 1780 made mid-19th c.? or 1825	not found yet		a c
barium sulphate	used 1782	1840s	Turner	d
Indian yellow	mentioned 1786	1781	Reynolds	a
Brunswick green	"new" in 1795	not found yet		e
opaque oxide of chromium	sold by Field 1815	not found yet		a
cobalt blue	1802 in France	ca.1806–1807	Turner	f
chrome yellow	1814–1815	exh. 1814	Turner	a
pale lemon chrome	post 1814–1815?	ca.1822–1823	Turner	
chrome orange	post 1814–1815?	ca.1822–1823	Turner	
emerald green	disc. 1814	ca.1828	Turner	f
synthetic ultramarine	1826–1827 1857	ca.1851	Turner Campbell	a j
ultramarine green	prepared 1828, made 1854–6	not found yet		g
Chinese white	1834 in England	1835–1840 1852	Turner Hunt	a
viridian	1830s in France	exh. 1842	Turner	f
cobalt yellow	1831 in Germany made 1851, 1860 Eng	1873?	Whistler	a d
barium chromate	French pat 1840s	exh. 1843	Turner	h
strontium chromate	sold by Field	1835? 1857	Mulready Campbell	a j
orange vermilion	"new" in 1835	exh. 1843	Turner	i
chrome scarlet	1840 W&N	ca.1851	Turner	e
cadmium yellow	1843	1855	Millais	j, l
antimony orange	patented in England in 1847	not found yet		c
zinc chromate	1850	not found yet		g
cobalt violet dark	mentioned 1859	not found yet		e
cadmium orange	1860 Rowney	1872	Whistler	e
ultramarine red	dev 1870–1880	not found yet		g

Sources: (a) Harley, R. D. 1982. *Artists' Pigments c1600–1835. A Study of English Documentary Sources*. London: Heinemann-Butterworth; (b) Field, G. 1835. *Chromatography*. London: Tilt; (c) Friedstein, H. 1981. *Journal of Chemical Education* (58):291–95; (d) *Artists' Pigments. A Handbook of their History and Characteristics*. 1986. Ed., R. L. Feller. Washington: National Gallery of Art; (e) L. Carlyle, personal communication; (f) Bomford, D., J. Kirby, J. Leighton, and A. Roy. 1990. *Art in the Making: Impressionism*. London: National Gallery; (g) Gettens, R. J., and G. L. Stout. 1966. *Painting Materials: A Short Encyclopedia*. New York: Dover Publications; (h) D. Saunders and J. Kirby, personal communication; (i) Harley, R. D. 1987. Some new watercolours in the nineteenth century. *The Conservator* (11):46–50; (j) E. Sheldon, personal communication. Paintings are privately owned.

Figure 6 shows a detail of this painting, which was lined early in its history. Turner's techniques were similar, in that he would apparently apply any paint medium over any other to gain a beautiful but short-lived visual effect.

Some of Turner's imitators achieved effects that today appear similar to his, but without the shrinkage and disruption of the paint. Turner's paintings may have changed greatly with time, as the critic John Ruskin thought. Several of Callcott's paintings have numerous thin glaze layers and less wet working than Turner used. Callcott, Etty, and other contemporaries of Turner did not have the patience to wait until previous paint had dried before they added another layer, but they did use varnish interlayers so that later paint could be applied safely. The Pre-Raphaelites favored a disciplined approach, too, as is well known. Hunt's *Strayed Sheep (Our English Coasts)* has very detailed, localized layers applied to already dried paint throughout the foreground, and, like works by Mulready and Collins, has a very well-preserved surface today (Plate 36).

The other durable method is to use such slow-drying oil paint that wet working is possible, or to thin the paint so it forms a single layer. This was Whistler's method in the early 1870s, when he was producing nocturnes and harmonies (13). Instead of allowing the paint layer to grow thick, he scraped it back vigorously and began again, sometimes using paint so wet that the canvas had to be laid flat until it dried.

British artists' adoption of new pigments, 1775–1875

Table 1 summarizes dates of invention, first publication, and so on, of pigments that became available between the eighteenth century and 1875, and notes the earliest occurrence yet found in oil paintings at the Tate Gallery.

Reynolds was known to experiment with paint media, and he might be supposed to have tried out new pigments too. Five of his works have been examined, including three at the Tate. Not surprisingly, all five include traditional pigments such as lead white, ivory black, asphaltum, vermilion, and Naples yellow, while one or more included red lead, orpiment, blue verditer, smalt, ultramarine, and green earth (14). Prussian blue, invented early in the eighteenth century, was used frequently by Reynolds. Some of this Prussian blue has a different microscopical appearance from the modern variety; similar material, previously illustrated in color by Welsh (15), was identified in Turner's paintings up to about 1840, when Turner began using the "modern" variety as well. George Jones used the modern variety in 1832. Reynolds also used Mars red from 1755–1760, and Mars orange, red, and brown in 1781. He used Indian yellow in a work dated to 1788, and wrote about a material that may have been Indian yellow in 1784, two years before it has been noted in the literature (16). Patent yellow has also been tentatively identified in a painting of 1781. Table 1 shows that all these instances demonstrate early uses of these pigments. Reynolds' organic pigments (red, blue, and a green made from yellow and blue dyes) are still being investigated.

Turner's early use (1800–1850) of new pigments in oil, summarized in Table 1, has been described elsewhere (17). While it is true that more paintings by Turner than other individual artists have been analyzed, the inference that he was more innovative than his contemporaries is inescapable. Turner used Mars colors frequently, as did many of his fellow British artists, including Constable from circa 1810 (18). In contrast, Arnald, Farington, Hilton, and Callcott used only well-established pigments such as ultramarine, Prussian blue, Naples yellow, and vermilion. Artists who used new pigments quite soon after their introduction include the following: Constable—cobalt blue in 1817–1818, chrome yellow in 1816, and opaque oxide of chromium in 1837 or earlier; Briggs—chrome yellow and orange in 1826; and Mulready—emerald green in 1842 (19). Barium chromate and a pigment tentatively identified as strontium yellow were found in a Mulready of 1835. Cadmium yellow has been found in a Millais of 1855, and strontium yellow in a Campbell of 1857 (20). The latter included synthetic ultramarine, rarely used before 1850 except by Turner, because it had a poor reputation (21). Whistler used two shades of cadmium yellow regularly from 1864 (the earliest of his works at the Tate), and strontium yellow in two works circa 1864–1871 and in 1872, respectively (22). The earliest tentative identification of cobalt yellow (mixed with barium chromate) is in one of Whistler's oils from the following year. No examples have yet been found of the cobalt violet shades that were available by the end of this period or by 1900.

White pigments and their fillers are also interesting. Artists from the time of Reynolds and Romney tended to use lead white with pipe clay or china clay extenders, both for priming and paint. Gypsum has been found in many paint samples from Reynolds and Wright of Derby in the later eighteenth century (23). Zinc white was very rarely found in Turner's oils, and not yet in his fellow Royal Academicians works painted before 1847. But Hunt used it in 1852, with lead white for a local imprimatura under the sky of *Strayed Sheep (Our English Coasts)* and with Prussian blue, presumably supplied as a tube of paler "Antwerp blue." Barium, attributable to barium sulfate, has been found as an extender in Turner's paintings of the 1840s, in the Hunt piece, and very frequently in Whistler's white paint from 1864–1875, and beyond.

A discussion of pigments that fell out of use during this period would be out of place here, but work is continuing in this area (24). Analyses of the paint media used by the artists mentioned here also continue, but as yet there are insufficient results for comparisons between Turner and many of his contemporaries.

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Abstract

Several of Whistler's paintings were examined and, where possible, analyzed; specific examples of pigment and media analyzes are given. Literature sources were searched for references to the artist's materials and methods. This paper describes Whistler's interest in texture, his use of dark gray grounds, his limited color ranges and careful preparation of the palette, his frequent erasure of his unsuccessful work, and details of his studio practice and portrait techniques. Probable changes in the appearance of his work are also discussed.

Art for Art's Sake: The Materials and Techniques of James McNeill Whistler (1834–1903)

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Introduction

Several of Whistler's oil paintings were studied in detail; works in the Tate Gallery, in particular, were analyzed and examined before conservation treatment using a full range of analytical techniques. Paintings in the Hunterian Art Gallery, Glasgow from the Birnie Philip bequest were also examined in detail and in some cases analyzed (1). Paintings in the National Gallery of Art, Washington were examined in conjunction with their conservation records. Several other works were examined or viewed in isolation; finally, the paintings in the Whistler Exhibition (1994) were inspected on arrival at the Tate Gallery (2). It has therefore been possible to make some interesting observations about Whistler's materials and techniques, based on detailed examinations of selected works and supported by the wider survey, and to compare them with the literature on Whistler's methods. This interpretation may be useful in understanding the present condition of his works and in helping to decide appropriate conservation treatments. It is also of general interest for the viewer wishing to appreciate a particular painting.

Supports

From the 1880s, Whistler frequently carried small panels for sketching, focusing particularly on street scenes, views of the sea, and figure studies. Some of his nocturnes and early studies were also on larger panels. The scale of these works was small because he painted distant views approximately the size that they appeared to him. For his major finished paintings and portraits, however, he worked on canvas, which provided a texture he liked. He often chose quite heavy canvases and applied thin grounds in order to preserve their texture. On other occasions he might paint on a fine canvas, then have the painting glue-lined onto a coarser one very soon after completion or even during the time of painting. He did this quite deliberately and there is evidence that he wished to imitate the lined appearance of old master paintings (3). His later work, such as *Mother of Pearl and Silver: The Andalusian* (1888–1900), illustrates this desire to express the canvas texture.

Grounds

Whistler's grounds were crucial to his methods. He came to London shortly after the Pre-Raphaelites had taken the use of smooth white grounds and intense color to extremes; some of his early grounds appear to be the white, commercially available grounds of the mid-century. Yet Whistler's training in Paris with Charles Gleyre (an academician who specialized in subjects taken from his travels in the Middle East), his early interest in the methods of the French Realists, and his experience with pastel, etching, and drypoint were more important influences. Whistler frequently applied a light gray imprimatura of oil paint on top of the ground to allow him to paint directly in a mid-ground technique. This technique is most easily observed in his small sketches on panel, for example, *Note in Red: The Siesta* (1883–884) (Fig. 1). After 1871 he increasingly used darker gray, exploiting the ground to develop full chiaroscuro effects in his later works, often setting his figure against a dark background. A photograph of his studio reveals that he had a black cloth



Figure 1. James Whistler, *Note in Red: The Siesta*, 1883–1884. Oil on panel. Daniel J. Terra Collection.

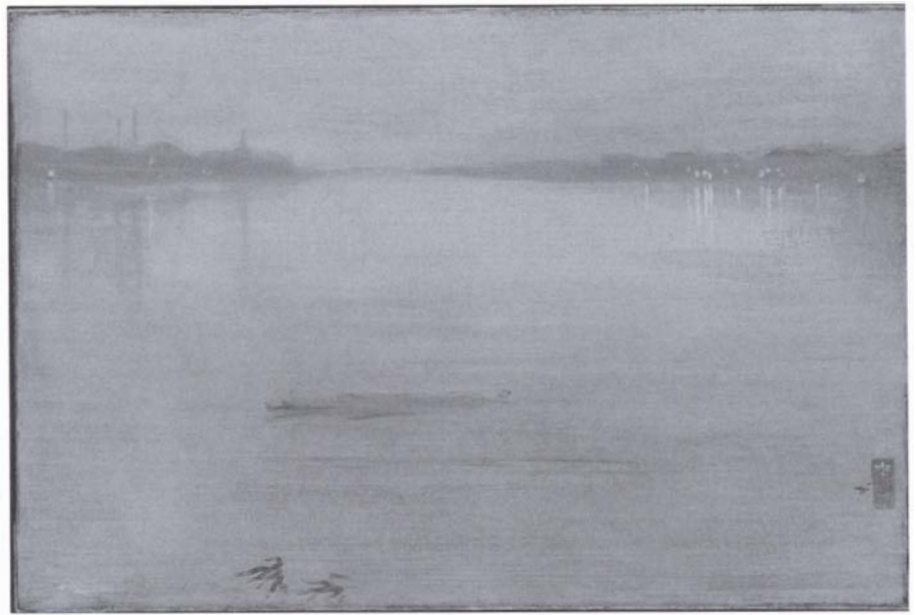


Figure 2. James Whistler, *Nocturne in Blue and Silver: Cremorne Lights*, 1872. Oil on canvas. The Tate Gallery, London.

to drape over an easel behind the sitter. Dark grounds were first successfully exploited by Whistler to produce his nocturnes of the 1870s. Similarly, for his watercolors, designs, and etchings, Whistler also sought old mid-toned or dark papers to form the basis of his images.

To make dark grounds, he mixed ivory black and lead white, frequently modified with other pigments. In his Chelsea studio, the Greaves brothers helped him prepare his materials. Walter Greaves describes his ground as a very absorbent distemper, indicating that at this stage Whistler was not only modifying commercial grounds but also preparing his own (4). The production of nocturnes was a period of experimentation. *Nocturne in Blue and Silver: Cremorne Lights* (1872) (Fig. 2) is on a partially scraped down, reused canvas from an earlier series with an unmodified, lighter commercial ground, whereas *Nocturne in Blue Green: Chelsea* (1871) has a dark ground applied over a white commercial priming on a mahogany panel. *Nocturne in Black and Gold: The Fire Wheel* (1875) has no commercial ground, only an artist's priming over the sized canvas. This ground consists of ivory black, chrome or cadmium yellow, and small amounts of lead white.



Figure 3. Brushes, paints, palettes, and other painting materials. Courtesy of the Hunterian Art Gallery, University of Glasgow, Birnie Philip Bequest.

Palette

Several of Whistler's palettes survive, along with his brushes, charcoal, engraving tools and tube paints, presumably dating from the last period of Whistler's life before they were donated to the Hunterian Art Gallery (Fig. 3). These have been examined and analyzed during the present study (5). For a short time (1898–1901), Whistler taught at the Académie Carmen. Reports by students of his methods demonstrate Whistler's concern for the preparation and layout of his palette. Colors were laid out in a specific order across the top of the palette from left to right: Prussian blue, cobalt blue, raw umber, burnt sienna, raw sienna, yellow ochre, a large blob of lead white, vermilion, Venetian red, Indian red, and black. Flesh tones were mixed just below the white, using the appropriate surrounding colors, and in turn these tones were modified by the black which was spread in a broad band curving downward. A preparation for the background color was mixed at the left. He then worked out all the colors and tones for his composition on his palette before placing any paint on his canvases. So obsessed was he with this "scientific" method that he would frequently examine his students' palettes yet ignore their paintings, wishing (he claimed) not to interfere with their individuality and free expression (6).



Figure 4. James Whistler, *Harmony in Grey and Green: Miss Cicely Alexander*, 1872–1874. Oil on canvas. The Tate Gallery, London.

Although this is a description of Whistler's late work, the artist acknowledges that he learned his approach from Gleyre and therefore would have employed similar methods throughout his career, with either a wider range of pigments or less mixing of pigments in his earlier work. Menpes confirms the attention to the palette but attributes to him the use of more intense lemon and cadmium yellows placed next to the ochre, and the use of rose madder instead of the Venetian red (7).

Whistler kept a great number of brushes, many of which he used at a single sitting in order to prevent his dominant hues from becoming further mixed. He spent much time cleaning and preparing these brushes, sometimes trimming and changing their shape. He had various types, including decorator's brushes to lay in grounds and backgrounds and extremely long-handled brushes for his portrait technique.

Pigments analyzed

Analysis of pigments found on Whistler's paintings confirm the use of complex mixtures of pigments usually involving at least some ivory black. Frequently, the same pigments are found mixed in different proportions throughout a painting. In nocturnes, mixtures of lead white, ivory black, cobalt, Prussian blue, and ultramarine have been found. By these means, Whistler produced his harmonies. For instance, *Harmony in Grey and Green: Miss Cicely Alexander* (1872) has a gray background, but this is an optical mixture of several colors based on lead white and ivory black (Fig. 4). The same colors occur in the superficially white dress. By restricting the saturation and hue of his colors throughout the scheme, Whistler could model his forms without introducing discordant hues typical of the works of many nineteenth-century painters influenced by the Pre-Raphaelites and exploiting a range of unmixed pigments. This restriction allowed him to explore subtle color effects; for example, he could choose to highlight a red as in the *Arrangement in Flesh Color and Black: Portrait of Théodore Duret* (1883–1884), intensified by the blacks and reflected in the grays of the rest of the composition (Plate 37). Whistler also subdued his colors by painting over a dark ground; in addition, he was able to use the coolness of his ground to give his thin scumbles a cooler tone than thicker applications of identical paint. This is most easily seen in the depiction of the rush matting on which *Cicely Alexander* stands.

Application

The actual application of paint followed several stages of development throughout his career. His early oil paintings, influenced by Courbet and the realist school, were quite thickly painted, very directly brushed with impasto. They have a tactile quality as in the rocks of the *Coast of Brittany* (1861). Although quite different in subject matter, *Symphony in White No. 1* (1862), now in the National Gallery of Art, is in a similar technique. It is on a coarse canvas with a commercial white ground, onto which Whistler has applied his own gray imprimatura. The head and hand are out of key with the rest of the work because they have been repainted following lining of the canvas. In *Symphony in White No. 3* (1865–1867), Whistler applied his paint quite thinly with fine but stiff hog's-hair brushes, leaving distinct and delicate lines on the surface. The success of this thin, sketchy application must have encouraged him to explore such methods further. In his portraits he claimed to paint *alla prima*, thereby retaining the tactile quality of his brush marks and his wet-in-wet application. To do this he needed to work quickly and confidently; however, he came far from achieving this ideal. Therefore, he would sometimes be obliged to scrape off his entire work at the end of a day and restart at the next sitting. He would also clean off his palette and make up a new one the following day. Possibly from his experience of earlier overworked paintings, he feared excessive alteration; therefore, if he was dissatisfied, rather than add too much overpaint he would rub or scrape off as much as possible of the image, often damaging the ground and exposing the canvas-weave tops (Fig.



Figure 5. Detail from Cicely Alexander, showing areas scraped down to the canvas.

5). There are many such examples of scraped down paint that have not been entirely painted over (i.e., *Cicely Alexander*) and there must be even more that are no longer visible. Although tiresome for the sitter, this approach was essential to the artist. The harmony would not survive if the pigments were not all mixed in a single operation on the same palette. His paint is essentially opaque with little or no deliberate glazing. Discolored glazes would also destroy the harmony. Therefore, as a rule, all his transparent pigments were mixed with opaque.

A further constraint in the studio is described by Walter Sickert (8):

Whistler was a great portrait painter, and prided himself on the precision of his portraiture. Whistler also had extensive knowledge, and knew that the eye could only see at a glance an object which in size is one-third of the distance between the eye and that object. In other words, if you are painting a man six feet high you should be 18 feet away from him. Whistler had a very long studio, and he was accustomed to place his model against a black velvet background, and alongside his model he placed his canvas. His painting table was 18 feet away. He would stand at the painting table, carefully survey the model, then charging his brush with the requisite pigment he ran at full tilt up to the canvas and dropped it on the spot.

This unlikely scenario is consistent with the small scale of much of his work and the flatness of the space around and behind his models.

In his nocturnes, Whistler's paint was extremely dilute. He mixed his oil paint with large amounts of turpentine and also added mastic varnish to produce a paint that could be brushed freely and did not dry too matte. He called it his "sauce" and analyses at the Institute for Atomic and Molecular Physics in Amsterdam confirm its formulation from mastic and a drying oil. In his later work he may have used newly available petroleum oil, as recommended to him by Sickert in 1885. In portraits such as *Arrangement in Yellow and Grey: Effie Deans* (1876–1878), he has allowed paint to run down the canvas, indicating just how diluted it was. His nocturnes were painted quite quickly (in a day) with minor modifications the next day, as Whistler freely admitted in his libel trial with Ruskin. The dark passages were first brushed in umber and black, or were simply the part of the imprimatura left exposed. Then a layer of "sauce" was applied using a large brush to scumble over the shadows and develop the lighter parts. The color and tone were controlled mainly by the thickness of application. The paint was worked wet-in-wet, scraped, rubbed, and even dragged across the wet surface, as in the reflections in *Nocturne: Blue and Silver* (1872) (Plate 38). Finally, details such as highlights were applied, after which the nocturne was put outside to dry in the sun. When it was dry, perhaps the next day, further details could be applied, preferably from the same palette, but reworking was not possible at this stage.

Condition and changes with time

Changes in appearance have occurred on many of his works and, despite his frequent scraping down, minor adjustments to compositions—such as the positions of arms and feet—are now evident. Most significantly, many works have become darker and cooler as the thin paint has increased in transparency over the dark ground. Similarly, the small sketches with medium-toned grounds have lost contrast in the mid-tones. His earlier, more decoratively colorful work on light grounds or thickly painted work, although flawed in detail, has preserved its appearance much better and is more readily appreciated. The darkness of much of Whistler's later work is due, in part, to changes resulting from dark grounds and also possibly from the darkening of medium, but to some extent the effect was intended.

Whistler appears to have always varnished his work and now many of his varnishes are excessively darkened and yellowed. In particular the discolora-

tion of varnish has dramatically affected the cool tones of nocturnes and some portrait backgrounds.

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Abstract

This paper discusses aspects of paintings executed on a photographic substrate. Inspired by Mervyn Ruggles's research into the use of this practice in the nineteenth century, this discussion presents examples of materials and techniques that have been proposed, manufactured, or employed for this purpose over the last 100 years. Information on this subject was gathered from the available literature and through personal communication with artists engaged in producing this type of artwork, as well as through discussions with manufacturers and museum personnel. North American and European instances are included, and details regarding the works of contemporary artists, such as Lynton Wells, Shirley Wiitasalo, Anselm Kiefer, and James Turrell, are noted.

Painting on a Photographic Substrate: Notes Regarding Materials and Techniques over the Past 100 Years

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Introduction

The idea of painting over photographic images has been present since the invention of photography. Sources regarding materials and techniques appropriate to this process have varied; some information has appeared in scientific and photographic publications. Communication with a number of contemporary artists, though, has shown that such literature rarely directly influenced their work. The principal factors guiding their production tended to consist of a willingness to experiment, a general awareness that such media may be combined, and the fact that this combination may serve their particular aesthetic or intellectual aims. The photographic image has also not only served as a replacement for the underdrawing, as was noted by Mervyn Ruggles in cases of nineteenth-century portraiture, but has been employed for a variety of purposes (1).

The following presents a brief discussion outlining the evolution of materials and techniques over the last 100 years. The discussion culminates in a focus on contemporary practice since the 1960s, a period in which the painter's use of a photographic substrate became more widespread.

From the late nineteenth century to 1950

In the late nineteenth century, improvements in photographic technology and the availability of commercial products made it far easier for the artist to utilize such means in the painting studio. M. L. Winter of Vienna, for example, established an operation in 1877 for the extensive production of enlarged photographs on linen, and proprietary brands of gelatin-silver emulsion-coated linen were available from the 1890s (2, 3). The introduction of faster bromide emulsions in the 1880s also greatly reduced the difficulties associated with producing enlargements, thus de-emphasizing the need for specialists (4).

Oils were frequently used for painting on photographic images, but other materials were also proposed. Instructions published during the 1890s and thereafter commonly referred to the coloring of photographs on paper supports and were directed at those lacking artistic skills. Details regarding the media proposed for this purpose have been included here because this information provides a more complete range of the materials that may be encountered, as well as indicating the interests and concerns of the time.

A number of proposals for the coloring of photographs appeared in *Scientific American* during the 1890s. An 1894 article, reprinted from *Anthony's Bulletin*, recommended the use of transparent and covering colors. These colors were to be made by mixing dry powdered pigments with a medium consisting of 100 cc filtered albumin, 5 g ammonium carbonate, 3 cc glycerin, 4 cc liquid ammonia, and 25 cc water (5). Another article, deriving from *Photographisches Archiv*, noted the use of aniline dyes. These were dissolved in alcohol and applied on the reverse (6). Another article noted the use of oils, watercolors, and pastels. These materials were only to be applied over a preparatory layer. Gelatin was recommended for oils; shellac was recommended for watercolors and pastels (7).

A proposal, reprinted from the *British Journal of Photography*, for the use of wax media appeared in a 1919 issue of *Scientific American Supplement* (8). Two

recipes were described. The first recipe suggested combining 1 oz. white wax (bleached beeswax), 1 oz. carbon tetrachloride, 1 oz. turpentine, 1 oz. benzene (refined naphtha) and 1 dr (1/8 oz.) 0.88 ammonia. The second medium was described as an improved version consisting of 1/4 oz. white wax (Cera Alba), 1/2 oz. spike oil of lavender, 1 dr hard primrose soap, 2 dr gum elemi and 3 1/2 oz. turpentine. The author proposed using wax, based on the fact that wax, employed since ancient times, had proven its durability. The author's rationale was also based on the notion that many of the negative effects resulting from the use of oils and varnishes, such as darkening and yellowing, would be avoided.

A 1934 edition of a manual describing the use of various media for coloring prints on paper noted that enlargements were to be mounted on beaver board, three-ply board, or linen canvas, and then stretched (9). Adhesive residue and dirt were to be removed before the application of a preparatory layer. This layer was to consist of either a 25% solution of glacial acetic acid, gelatin, and Lepage's Liquid Glue in water (1:20), or a mixture consisting of 3 oz. of paste (made from 1 oz. pure casein, 180 g powdered borax, 3 oz. water), 3 oz. alcohol, 5 drops glycerin, and 5 drops carbolic acid. The image was then ready to be painted with oils, watercolors, or a medium consisting of tempera colors and the casein mixture.

The 1936 edition of a manual on retouching stated that the best results for a portrait in oil were to be obtained by painting over a carbon print on canvas. A priming, consisting of a starch solution to which some mucilage had been added, was to be applied to the print before it could be painted. Reference was also made to the "Russian method" of coloring, in which layers of transparent oils were rubbed on with cotton (10). Materials recommended for this process included Marshall's Transparent Photo Oil Colors, Roehrig's Photo Oil Colours, or a combination of artists' oils and megilp.

The 1930s were also a period in which photographic developments expanded into an architectural context. Articles in architecture journals noted that photographic murals could be realized through the use of photo-mural paper or the spray application of light sensitive emulsions directly onto architectural surfaces (11, 12). The notion that a variety of materials could be employed as supports for photographic images was also reaffirmed by new developments in industry. The Glenn L. Martin Company of Baltimore, for example, reduced aircraft production time by developing an emulsion that enabled the full-scale reproduction of designs on aircraft materials (13). A commercial form of this emulsion was marketed following World War II (14). Articles outlining the use of such materials frequently noted the need for preparatory and protective layers, should the images be colored with oils or other media (15, 16).

After 1950

At the middle of this century, painters' attitudes toward the photographic image began to change. Manifestations of this attitude change included the Photo-Realist movement and Robert Rauschenberg's and Andy Warhol's use of photomechanical processes. The American artist James Couper, who has made use of 3M's Scanamural process (a computerized spray painting technique) to generate large-scale underdrawings for his paintings, has stated that he was drawn to this technique after learning how some Photo-Realist painters transferred images to canvas through an emulsion process (17). Studies published in the United States on the work of such painters, though, have contradicted this view. Patton, for example, has held that the intention of these painters was to comment on photography, not include it, and interviews conducted with a number of these artists have also not confirmed the use of any light sensitive coatings (18, 19).

This change in attitude toward the photographic image was also affected by a new interest in early and alternative processes that occurred during the

1960s in North America. Requiring both a hands-on approach and minimal resources, these processes appealed to those who felt that the elements of urban life, such as high technology and mass-produced goods, were worthy of rejection. Interest in these processes became widespread and resulted in a number of publications that provided information on various techniques (20, 21, 22, 23).

Commercial products, such as emulsion-coated canvas and ready-to-use emulsion, became more widely available at about the same time. Argenta, which operated in Munich, Germany, developed an emulsion-coated canvas in the late 1950s and early 1960s (24). Designed for theater use, advertising purposes, and the reproduction of stitches, this Photoleinen, or photo linen, was first marketed in 1962. The product was actually made from a cotton fabric prepared with a pigmented gelatin layer. The pigmenting agent comprised a mixture of baryta sulfate and titanium oxide. The photographic emulsion applied to the gelatin-coated fabric was the same as that used in the manufacture of baryta papers of medium gradation. It was also unwashed, that is, all superfluous salts were left in the emulsion. A 1991 product list from Luminos Photo Corporation of the United States listed the availability of sheet and roll forms of a similar product. The sheet form had been impregnated with a bromide emulsion, and the roll form with a chlorobromide emulsion (25).

New lines of ready-to-apply photographic emulsions also became, and continue to be, available. One version, developed by Argenta of Munich, was described as suitable for most surfaces (26). Poor adhesion was to be remedied with a preparatory layer of varnish; metallic surfaces were to be precoated with gelatin. Print-E-Mulsion, a version developed in the United States, first appeared in the mid-1970s (27). At the end of the 1970s, the name was changed to Liquid Light.

Contemporary painters

Several contemporary painters have employed such materials in their work. The American artist Lynton Wells generally used a canvas manufactured by Argenta. This was used in the production of paintings and sculptures from the late 1960s until about 1983. In some of these paintings, a single image spanned multiple panels, where the total length could exceed four meters. To create these works, the artist tacked the photo linen to the studio wall and exposed the material in situ. To ensure that the image was properly aligned when the canvases were stretched, the tacking margin of each section was carefully folded under, before the edges of the canvas were put in contact. Processing was done in homemade developing trays and the images finished with one or more media. Oils, acrylics, aniline dyes, pastels, and charcoal were applied in varying densities. Frequently, these additions mimicked elements present in the photographic portion of the image. Wells also normally applied two to three layers of an acrylic polymer before painting with oils (28).

Other painters who have made use of photographic bases in their work have included Arnulf Rainier of Austria, Shirley Wiitasalo and Kathleen Vaughan of Canada, Anselm Kiefer of Germany, and Fariba Hajamadi and James Turrell of the United States. From the late 1960s through the 1970s, Arnulf Rainier used photographs, photographs mounted onto wood or aluminum, and photo linen (29). The range of media employed in these works included oils, oil crayon, pencil, and ink. Portions of the photographic image remain visible in many of his works, but in some it has been completely negated by the thick application of paint.



Figure 1. Shirley Wiitasalo, *Interior*, 1981. Oil and photo emulsion on canvas. Photograph courtesy of National Gallery of Canada, Ottawa.

Shirley Wiitasalo created the 1981 painting *Interior* by applying Liquid Light over a stretched cotton canvas prepared with an acrylic gesso (Fig. 1). Exposure was carried out using a slide projector. The image was then finished with Bellini oils and left unvarnished (30). As one of a series of paintings dominated by the television screen and featuring ambiguous and distorted

imagery, it was the only work in which a photographic emulsion had been employed (31).

Kathleen Vaughan's painting technique has also involved the use of Liquid Light. In some of her work, the emulsion was applied directly to the canvas and processed by sponging chemicals over the support. Areas of the canvas that the artist intended to appear similar to the photographic portions were stained with a distemper medium. These layers were then isolated with a coating of an acrylic varnish; texture was applied with acrylic media and the final details in oil. Due to allergies, the artist has only used linseed oil to thin her oil paints (32).

Anselm Kiefer has become well known for his robust paintings in which photographic enlargements, mounted on canvas, support oil, acrylic, shellac, straw, sand, and lead additions. Kiefer's photographic underdrawings have been printed on Dokumentenpapier P 90. The harsh or catastrophic appearance of these images was created through the manipulation of lighting or processing methods (33). Although the photographic image remains visible in some of the paintings, a number of them have been completely overpainted. In such cases, only the excess of support material on the reverse of the stretcher may provide evidence as to the presence of a photographic substrate (34).

Since the late 1980s, Fariba Hajamadi, an Iranian-born painter living in New York, has combined paint and photographic images to produce fictitious interiors (35). These paintings have been made by brushing a commercially available photographic emulsion directly onto cotton canvas or wood. This method was selected to enable the texture or grain of the support to contribute to the composition. Following exposure and processing, an airbrush was used to apply color. The paint, a commercially available transparent oil paint, had been thinned to the appropriate consistency with lacquer thinner (36).

In the planning for his "Roden Crater Project," James Turrell has produced studies on frosted drafting mylar in which wax, photographic emulsion, and various paint and graphic media have been combined (37). These studies were created in the following way: A coating of hot beeswax was first sprayed onto the mylar. This wax layer was then coated with a photographic emulsion and the desired image of the crater exposed and processed. The image was then manipulated and elements may have been removed with an eraser or by scraping with a knife. Frequently, wax pastels were used to replace removed portions, make additions, or enhance or blur particular details. The colors used were carefully chosen so that the additions might stand out or coalesce with the existing image. In some cases, a type of sandwich was made by dry mounting drafting vellum to the emulsion-coated surface. Further details were then added to the front or back of these studies with ink, paint, graphite, or wax pastels (38).

Conclusion

Painting and photography are techniques that have frequently been used in conjunction with each other. For the most part, this relationship has been based on visual and intellectual concerns, not the material union of media. This paper has attempted to illustrate that although painters may not always have utilized photographic materials in their work, information regarding this possibility remained available and contributed to related and/or contemporary forms of art production. The genre of traditional portraiture was excluded from the discussion; while some portraitists may have utilized such materials in the past, recent examples of this were not found.

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Abstract

It is argued here that painters of the Baroque adhered to the die-hard tradition of loading their palettes with a limited number of tints, suitable only for painting the passage they planned to finish in that stage of the work. Support for this proposition comes from various directions: written sources, studio representations, and scientific research generated by different methods. An example of a specific studio practice is used to demonstrate the much discussed interrelation of technique and style.

Reflections on the Relation between Technique and Style: The Use of the Palette by the Seventeenth-Century Painter

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Introduction

In the *Vitae*, as is widely known, Giorgio Vasari attempted to describe the development of Italian art from Giotto onward as a process of continuous progress culminating in the work of Michelangelo. The idea that art changes because better solutions appear was certainly not restricted to Vasari. While stylistic developments in Western art were viewed as a matter of progress, it was inevitable that the characteristics of earlier styles would be explained in relation to problems that had meanwhile been solved. This could apply to the invention of perspective and to the invention of oil painting—which, according to Vasari, “softens and sweetens the colors and renders them more delicate and more easily blended than do the other mediums” (1). Finally, the development of style can be applied within oil painting to the development of the technique for achieving a “glowing” incarnate, as Karel van Mander termed it, by means of an underpainting in vermilion that “glows more fleshy” (2).

Viewed thus, there can be said to exist a clear relation between style and technique. During the nineteenth century, however, this was a hotly debated issue among art theorists. Some of these, especially writers on architecture such as Gottfried Semper (1803–1879) and Viollet-le-Duc (1814–1879), aimed to demonstrate a fundamental interrelation of style and technique in the arts (3). Twentieth-century developments, such as the theories underlying the Bauhaus, continued to build on the same ideas.

Not everyone agrees that style and technique are interrelated. A parallel stream of art history adheres to the idea, current since the Romantic period, that every form of art had its own formal legitimacy. In this way of thinking, it was not necessary to explain styles in terms of technical limitations and possibilities. This line of thought culminated in the concept of *Kunstwollen*, originated by Alois Riegl (1858–1905), which was seen as the manifestation of an “urge to form,” independent of the restrictive influence of such factors as function, materials, and technique. All the same, Riegl did not deny the influence of technique. He believed, however, that *Kunstwollen* overcame the technical limitations. Technical frontiers, considered by Semper to play a positive part in the creative process, constituted in Riegl’s view a “coefficient of friction” within the *Gesamtprodukt* of *Kunstwollen* (4).

It could be argued that Riegl’s notion of *Kunstwollen* was partly responsible for the fact that “style” has so long remained one of the main domains of art historical research, with art historians such as Wölfflin and Focillon being prominent representatives of this direction. It is worth noting here that the stylistics of Wölfflin were dominated by an outlook in which the autonomous or even abstract qualities of the visual vocabulary took priority over the pictorial means employed to achieve a convincing representation of reality.

Since Wölfflin’s times, research into artistic techniques has become more and more detached from stylistic considerations. Owing to the shift towards sci-

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Figure 1. Jan Baptiste Collaert, *Color Olivi*, 1566–1628. After Johannes Stradanus. Courtesy of the Rijksmuseum-Stichting, Amsterdam.

entific research methods, research into historic techniques has now come to play a central part in research on authenticity and workshop practice, as well as in conservation and restoration.

Research into historic techniques has made considerable progress in these areas during recent decades, so it now makes sense for current applications and future research to turn renewed attention to the interrelation between technique and style. This interrelation is examined here through the study of developments affecting the painter's palette.

Palettes

One of the most fascinating and complete documents concerning the history of the art of oil painting is a well-known engraving by Jan Baptist Collaert, after Stradanus, which dates from the end of the sixteenth century (Fig. 1). This engraving gives a highly detailed picture of an idealized painter's studio: the master is working on a history piece, while an assistant is occupied with painting a portrait. Two other assistants are grinding and preparing colors. The engraving shows countless details that provide valuable hints about day-to-day practice in the late-sixteenth-century painter's studio. In the foreground, three boy apprentices can be seen; the smallest is practicing the rudiments of drawing, and the more advanced apprentice on the left is drawing from plaster casts.

For our present purposes, we are solely concerned with the apron-clad apprentice standing next to the master. He is setting out a palette of small shells, presumably containing colors prepared by the assistants, and holds a palette similar to that of the master. As it will soon be made clear, the arrangement of the master's palette with so few colors is far from arbitrary. Like so many other details, this must be regarded as a faithful representation of sixteenth-century practice. The youth in the foreground has applied a limited number of colors to the palette in his hand. As on his master's palette, they are spread out over the surface of the palette.

There are generally no written sources to be found on the most routine activities of the painter's studio through history. Incidental evidence on certain aspects of painterly practice can be gleaned from documents, but we have to live with the fact that such sources are extremely sporadic in both time and place. In the present case, a late-seventeenth-century Italian text can be shown

to relate to the activities depicted on the previously mentioned engraving by Collaert, which originated a hundred years earlier in the Netherlands. Using available sources in this way is, of course, only justifiable when the phenomenon being investigated is widespread and displays a certain constancy. The considerable mobility of painters in the sixteenth and seventeenth centuries provided many opportunities for the spreading of painterly techniques and procedures. Many young painters traveled across Europe and worked in the studios of various masters for shorter or longer periods; a similar situation still exists in the international art restorers' world. This form of mobility ensured a rapid dissemination of knowledge and experience, leading to a high level of international uniformity in knowledge and craft practices. Bearing this in mind, one might venture a cautious guess that the question of what the youth with the apron is doing in the studio of Stradanus could be answered by a passage from the Volpato Manuscript, a seventeenth-century Italian document. This text by Giovanni Battista Volpato (born in 1633) must date from somewhere around 1680, and was written in the form of a series of dialogues. It contains the following exchange between F, an older painter's apprentice, and Silvio, a younger apprentice (5):

Silvio: Tell me, if you will, whether you set your master's palette.

F: Surely. . . . It suffices for him to tell me what he intends to paint, for I then know which colors I must place on the palette.

The engraving after Stradanus and this late-seventeenth-century text provide two of the few hints—which until now have not been given any consideration in the literature on art history and painting techniques—that painters formerly used palettes which were set with groups of colors specifically for certain parts of the painting, and which thus did not include all the available pigments. This understanding of the situation has a far-reaching consequence: one must then see the seventeenth-century (but also earlier or later) painting as a composite image made up of interlocking passages, comparable to the *giornate*, the successively executed “daily portions,” of fresco painting, although in the case of oil painting, a number of passages would have generally been completed on a given day (6).

In using such a method, the seventeenth-century way of painting differed fundamentally from the approach of late nineteenth- and twentieth-century artists, namely in developing the painting as a tonal entity. For example, the Hague School painter Jozef Israëls used a palette with a full range of colors and with a mixing area covered with patches of mixed paint, of which the tone and color could be further modified. A palette of this kind enabled the artist to continue working over the whole area of the painting simultaneously, with an eye to controlling the tonal consistency of the painting.

In the first instance, the idea of earlier artists working in *giornate* as described above may sound highly exaggerated. After all, we know that the great majority of seventeenth-century painters did in fact conceive their painting as a tonal unity, as is evidenced by the practice of starting with a largely monochromatic or “dead color” underpainting (7). The point of importance here is that after laying in the underpainting, the artist developed the composition further by successively adding islands of modulated local color. Once this is understood, it becomes clear that a painting such as Rembrandt's *Jewish Bride* has far more in common with work of predecessors such as Raphael than with the paintings of Jozef Israëls and his contemporaries, however much inspiration Israëls drew from that painting.

A method such as that described is intimately connected with the material, technical, and economic constraints that were inherent to oil painting, constraints that only vanished (and were subsequently forgotten) with the introduction of ready-to-use, “mutually compatible” tube colors (8).

The early palettes were small. Only in the course of the nineteenth century did they grow to the size of small tabletops. It will be clear that this relatively

sudden increase in the dimensions of the palette is part of the argument put forth here (9).

When one studies the distribution of various tints on the countless palettes that appear in paintings, it is impossible to avoid the impression that the painters adhered strictly to a certain set of rules. This is certainly true for the period after about 1600. Prior to that time, the palette was ostensibly set with relative freedom. But it is precisely in those earliest representations of palettes that it is sometimes obvious that the palettes were set up specifically for each passage to be painted.

Niklaus Deutsch's painting *St. Luke Painting the Madonna* (1515) is typical of a group of paintings completed in the fifteenth and sixteenth centuries, in which St. Luke is in the process of painting the Madonna's robe. The depicted artists' palettes show a limited number of patches of paint, with various shades of blue as well as black and a little white. These are exactly the colors needed to render the modeling in the drapery of the blue robe—distributed apparently at random over the surface of the palette (10). In paintings of the same period in which St. Luke is painting the naked Christ Child or the face of Maria, the palette carries the range of colors needed to mix the various tints of the flesh: white, yellow ochre, vermilion, red lake, various browns, black, and sometimes terre verde (11).

As explained in the following discussion, the flesh tint, like blue, had an important status. The colors for painting the human skin were not yet systematically arranged on the palette before 1600, but appear to be distributed at random. For example, the position of the white paint differs from one case to another on earlier palettes. From 1600 onward, studio scenes and self-portraits depict palettes with a row of lumps of paint spaced evenly along the top edge. The range of colors depicted normally runs from a somewhat larger portion of white near the thumb, to yellow ochre, vermilion, red lake, and then through a series of progressively darker browns to black. Alternately, the vermilion is sometimes placed between the white and the thumb. This arrangement agrees with a passage in the Mayerne Manuscript: "It is to be observed, moreover, that in setting the palette, the lightest tints must always, without exception, be placed at the top and the darker tints lower down" (12). It is striking, and very significant in the context of this article, that the author has found no instance of the depicted standard palettes from either before 1600 or afterward that includes any intense green, bright yellow, or blue paint. These are what are called, in the Mayerne Manuscript of 1630, "the strong colors" (13). The reason for the absence of these colors is clarified by the following.

In the Volpato Manuscript, the older apprentice tells the younger that his master merely has to indicate what passage is to be painted in order to lay out an appropriate palette. This statement implies the existence of fixed recipes for reproducing the various elements of nature. Around the same time, the Dutch painter Willem Beurs wrote down such recipes for the benefit of both "students of the Noble Painterly Art" and interested "amateurs" (14).

As an example, a recipe for painting a white horse follows (15):

One paints the illuminated side using white, light ochre and black, with pure white for the highlights; light ochre is recommended for the intermediate color, and it is advisable there to be rather sparing with white. For the shadow, black and light ochre must be mixed together with a little white; the reflection under the belly should be mostly light ochre, with sparing use of black and white. The hooves can sometimes be painted with black, white and light ochre, with a touch of vermilion; and sometimes with black, white, and umber. The color of the nose is the same as that of the hoofs. But as for the eyes: the pupil should be painted with bone black, and the rest with umber, black and white.

It is clear that if an artist plans to paint a white horse, the only pigments needed on the palette are white lead, yellow ochre, vermilion, umber, and

bone black; and if the painter expects painting the horse to be a day's work, no other colors need be prepared for that day, apart from the five pigments just mentioned.

It is notable that throughout hundreds of recipes of this kind, only a severely limited range of pigments is prescribed. This provides a piece of information that is of critical importance to the picture of the artists' practice being sketched here: paint was only ground and prepared when it was needed. It is precisely because painters wished to keep working without unnecessary delays and therefore found it advantageous to use paint that dried quickly (thus containing strong drying oils and other drying agents), that paint could not be kept for long. If the complete range of pigments, each already ground with oil, had to be available, this would mean that much paint would have to be thrown away unused. Hence the economic reasons for the method of working with restricted, specific palettes are clear. The technical background of this method will be discussed briefly in this paper.

It is significant that the series of recipes recorded by Willem Beurs concludes with flesh colors (16). Beurs writes as follows: "Just as we humans consider ourselves the foremost among animals; so, too, are we the foremost subject of the art of painting, and it is in painting human flesh that its highest achievements are to be seen" (17). The palette Beurs gives for painting human flesh comprised mixtures of the pigments lead white, light ochre, *schijtgeel* (an organic yellow), vermilion, red lake, tawny ochre, terre verte, umber, and "coal black" (probably ground charcoal which gives a bluish black). It was the palette for what was considered to be the summit of creation, and the most difficult subject of all to paint, the human figure. It is almost invariably the palette for flesh colors that is depicted in self portraits and studio scenes after 1600, paintings that are generally intended to represent the art of painting at its noblest.

It will come as no surprise to anyone who has examined fifteenth- or sixteenth-century paintings to any depth as material objects, that every passage was executed as a separate entity. The additive character of the painting as a whole is generally plain to see, despite the psychological compulsion perceptually acting on the viewer to transform the painting into a *Gestalt*.

Even though revolutionary developments during the seventeenth century brought the pursuit of pictorial unity to an unprecedented level, the sources quoted above suggest that no change had taken place in the tradition of using recipes for various components of the painting. The economic rationale for this approach has already been mentioned above. Originally, however, technical reasons may have provided an even stronger motivation for executing a painting as a series of successive passages.

For the twentieth-century painter, who normally regards paint as a pasty substance of a certain color that can be squeezed out of a tube, it is hard to imagine that to artists of not only the fifteenth and sixteenth centuries, but also through the first half of the nineteenth century, each pigment presented its own inherent possibilities and constraints (18). Some pigments could not be worked up with oil; some pigments could only safely be mixed with one or two other pigments; some pigments could only be used transparently and yet others only opaquely. Other properties, too, such as color permanence, workability, drying qualities, and so on, could differ so strongly from one pigment to another that it was normal to use a given pigment either in pure form or mixed with any of a limited number of other pigments in order to somewhat modify the tone and color (19). This helps explain why, in the work of artists such as van Eyck or Lucas van Leyden, the colors unmistakably interlock like the pieces of a jigsaw puzzle, and each color has an individual character, especially as to transparency, surface texture, and thickness of the paint layer. The most easily workable pigments were the earth colors, which ranged from yellow ochre through red ochres to the darkest brown tints and were varied in tone by mixing together and by the addition of white or



Figure 2. Neutronactivation autoradiographic image of Rembrandt's *Bellona*, 1633. The Metropolitan Museum of Art, New York. In this image the activated phosphorus atoms (from bone black) and mercury atoms (from vermilion, used on the figure's mouth) have mainly blackened the film.



Figure 3. The image of the autoradiograph in Fig. 2 is mainly determined by the radiation from the copper atoms (from the blue-green parts in the painting) and again the mercury of the vermilion.

blacks. Passages painted with mixtures of these pigments are subtle in their tonal values and graduations. Whenever it was necessary to achieve strong, bright colors (i.e., red, yellow, and blue robes), it is clear that the passage concerned was executed within carefully delineated contours in accordance with a fixed recipe, involving a specific layering or a fixed type of underpainting. This also explains why these colors are usually absent from flesh-color palettes depicted in studio scenes and self-portraits.

That artists worked in this way during the fifteenth and sixteenth centuries can easily be discerned from the paintings themselves. But did this practice continue into the Baroque period? In the case of Rembrandt, this is by no means self-evident. There were already indications, however, that Rembrandt must have used this method; it has been observed that he completed his paintings systematically from background to foreground, passage by passage, on the basis of a monochromatic underpainting (20). This does not necessarily imply, however, that he did this using a restricted palette. An important piece of evidence for that practice is supplied by scientific studies. It was the failure of a reconstruction project that, in fact, formed the seed of the study presented here. The preparation of a dummy Rembrandt using all the procedures of Rembrandt's studio that were known at the time was unsuccessful because the painting was executed using a complete palette. All the pigments that were in use during the seventeenth century were present on the palette and they were mixed on the same mixing surface, which was cleaned at intervals. Autoradiographic investigation of the dummy made it clear that the procedure used resulted in all the pigments being present to a greater or lesser degree all over the painting. By contrast, autoradiography of Rembrandt's actual paintings resulted in surprisingly "clean" images (Figs. 2, 3) (21).

In Rembrandt's painting, certain pigments occur only within clearly demarcated zones, not in the rest of the painting. This observation is additionally confirmed by studies of paint samples from Rembrandt's paintings, which time and again reveal that only a limited number of pigments were used in a given passage. The mixtures found usually consist of two to four different pigments; mixtures of five—or, in very exceptional cases, six—pigments are found only incidentally (e.g., in flesh passages). To achieve the typically Baroque tonal unity using such methods implies a highly developed level of "management" in the use of colors and tones. It is therefore no coincidence that artists began theorizing about the nature of this "management" during the seventeenth century. This was made clear by Paul Taylor's study of the term *houding* (roughly, "disposition") that appears regularly in seventeenth-century sources (22). Until some time into the sixteenth century, the picture space was still structured simply as a foreground with a background or *campo*, a concept on which Jeroen Stumpel performed an important study (23). The idea denoted by the term *houding* was a far more complex one, however. Seventeenth-century writers used *houding* to denote the spatial coherence created in the painting by the disposition of tones and colors. The viewer could "walk" through this space in his imagination. In a formulation by Willem Goeree (1668), *houding* is (24):

. . . that which binds everything together in a Drawing or Painting, which makes things move to the front or back, and which causes everything from the foreground to the middle ground and thence to the background to stand in its proper place without appearing further away or closer, and without seeming lighter or darker, than its distance warrants; so that everything stands out, without confusion, from the things that adjoin and surround it, and has an unambiguous position through the proper use of size and color, and light and shadow; and so that the eye can naturally perceive the intervening space, that distance between the bodies which is left open and empty, both near and far, as though one might go there on foot, and everything stands in its proper place therein.

When one considers how a painter would have been intensively concerned with obtaining a good *houding* while at the same time working with selective

palettes as described above, it is clear that the level of accomplishment required was of a quite different nature to the methods of painters from the later nineteenth and twentieth centuries, who, thanks to the full palette, could now work on the whole painting at once. This fact clearly explains the somewhat “muddy” effect, compared to earlier paintings, characteristic of Jozef Israëls and many of his contemporaries and successors.

Research into the borderline region between style and technique throws light on unexpected aspects of seventeenth-century studio practice. It is clear, for instance, that the view on the genesis of paintings presented here must have implications for scientific research into Baroque paintings. Analytical studies of the binding media used in the seventeenth century (e.g., by Rembrandt) suggest that a different blend of media is likely to be found in every giornata of the painting (25).

This study has produced a picture that may be relevant to the discussion of the interrelation of style and technique, namely that of a development of Baroque painting in which artists strove for a unified tonal image that did not appear to be composed by additive methods. The fact that these additive techniques were used gives a different picture of the artist at work, one in which technical limitations actually constituted the “coefficient of friction” (to use Riegl’s term) that thwarted the artists in their pursuit of a new style. It was even necessary for the seventeenth-century painters to introduce a new art-theoretical concept, namely *houding*, to bring the discussion of these efforts to a new level of abstraction. Only in the nineteenth century did the technical materials and means arise—namely, the full color palette, paint in tubes, and the associated large palette sizes—that made it possible to apply a technique appropriate to the painter’s stylistic aspirations (as exemplified by Cézanne’s remark, “You must understand that I handle the whole painting at once, in its totality”) (26). Semper appears to be borne out, on the other hand, if one observes that a late Rembrandt, placed between a Raphael and a nineteenth-century piece of “Rembrandtism” such as a late work by Jozef Israëls, shows closer kinship to the Raphael than to the Israëls. Indeed, the technique of additive painting has an unmistakable determinative effect on the style of a painting.

Acknowledgments

Thanks are hereby expressed to Jos Koldeweij, Hayo Menso de Boer, Paul Broeckhof, Dieuwertje Dekkers, Karin Groen, and Charlie Smid. Much of the research underlying this study was carried out within the framework of the Rembrandt Research Project, financed by the Netherlands Organization for Scientific Research, and also received valuable support from the Director and the Head of the Art History Department of the Central Laboratory for Research on Objects of Art and Science, Amsterdam.

Notes

1. *Vasari on technique*. 1960. Ed. B. Brown. New York, 230.
2. van Mander, K. 1604. *Den grondt der edel vry Schilderconst*. Haarlem, fol. 64r. P. Taylor of the Warburg Institute, London, is carrying out research on the concept “glowing” in connection with the painting of flesh in the early seventeenth century.
3. Semper, G. 1860–1863. *Der Stil in den technischen und tektonischen Künsten*. Frankfurt am Main. See also Viollet-le-Duc, E. E. 1863–1872. *L’entretien sur l’architecture*. Paris.
4. Riegl, A. 1893. *Stilfragen*. Berlin, v–xix, 20, 24. See also Kultermann, U. 1966. *Geschichte der Kunstgeschichte*. Vienna, 288.
5. Giovanni Battista Volpato: *Modo da tener nel dipingere*. 1967. In *Original Treatises on the Arts of Painting*. Ed. M. P. Merrifield. New York, 726–55, especially 746–48.
6. Mora, P., L. Mora, and P. Philippot. 1984. *Conservation of Wall Paintings*. London, 138–64.
7. van de Wetering, E. 1977. De jonge Rembrandt aan het werk. In *Oud Holland* (91):7–65, especially 20–24.

8. It is not clear when people first started keeping prepared paint in small pouches made of pig's bladder. The pouches are occasionally illustrated in eighteenth-century sources. According to R. G. Gettens and G. L. Stout (1942. *Painting Materials: A Short Encyclopedia*. New York, 318), the tube came into widespread use around 1840.
9. A description of the evolution of the palette can be found in Gettens and Stout, op. cit. (note 8), 299–304.
10. Colyn de Coter, *St. Luke Painting the Madonna*, Vievre, Alliers (near Moulins), ca. 1490; de Meester van het Augustiner Altaar, *St. Luke Painting the Madonna*, Germanisches Nationalmuseum Nürnberg, 1487; Nicolaus Manuel Deutsch, *St. Luke Painting the Madonna*, Bern Kunstmuseum, 1514–1515; Unknown Flemish Master, *St. Luke Painting the Madonna*, the Grimani Brevarium, fol. 781v, Bibliotheca Marciana, Venice.
11. Hinrik Bornemann, *St. Luke Painting the Madonna*, Hamburg, Jakobikerk, 1499; School of Quinten Massys, *St. Luke Painting the Madonna*, National Gallery, London; Derick Baegert, *St. Luke Painting the Madonna*, Landesmuseum, Munster, 1490. Belonging to the same category of palette are: Jacob Cornelisz van Oostzaenen, *Self Portrait of the Artist Working on a Portrait of his Wife*, Museum of Art, Toledo, ca. 1530; Catharina van Hemessen, *Self Portrait*, Öffentliche Kunstsammlung Basel, ca. 1548.
12. Pierre Lebrun, *Recueil des essais des merveilles de la Peinture*. In *Original Treatises on the Art of Painting*, Vol. II. 1967. Ed. M. P. Merrifield. New York, 770–71.
13. *Quellen für Maltechnik während der Renaissance und deren Folgezeit (XVI-XVII Jahrhundert)*, Vol. IV. 1901. Ed. E. Berger. Munich, 288–89.
14. Beurs, W. 1698. *De Grootte Waereld in het Kleen geschildert*. Amsterdam.
15. Beurs, op. cit., 165–66.
16. Beurs, op. cit., 184–87.
17. Beurs, op. cit., 186.
18. This standardization of the working properties of various colors of paint is achieved by the addition of fillers such as bentonites or aluminium hydrates, or by the use of alternative pigments. Naples yellow, for example, is substituted by a mixture of titanium white and cadmium yellow.
19. See for example the specifications given for the various pigments in a section about oil paint in *De volmaakte Verwer*, 1770. Amsterdam, appendix.
20. van de Wetering, E. 1977. De jonge Rembrandt aan het werk. In *Oud Holland* 91:7–65, especially 20–2. See also van de Wetering, E. 1982. In *A corpus of Rembrandt Paintings*, Vol. I. J. Bruyn, B. Haak, S. H. Levie, P. J. J. van Thiel, E. van de Wetering, Den Haag, 25–31.
21. Ainsworth, M. W. et al. 1982. *Art and Autoradiography: Insights into the Genesis of Paintings by Rembrandt, Van Dijk and Vermeer*, New York. For activities in the autoradiographic area by the Gemälde-Galerie and the Hahn-Meitner-Institut für Kernforschung in Berlin, see *Maltechnik/Restauro* I (1987):21 et seq.
22. Taylor, P. 1992. Harmony and Illusion in Golden Age Dutch Art Theory: The Concept of *Houding*. In *Journal of Warburg and Courtauld Institutes*. (LV):210–32.
23. Stumpel, J. 1990. *The Province of Painting. Theories of Italian Renaissance Art*. Utrecht, 131–174 (also published in: *Simiolus* 1989, 19 [3/4]:219–43).
24. Goeree, W. 1670. *Inleyding tot d'Algemeene Teykenkonst*. (First printing, 1668.) Middelburg, 219–43.
25. C.f. the article by C. M. Groen in the still unpublished publication in connection with the restoration of the late Rembrandts in the Rijksmuseum, Amsterdam.
26. “Je mène comprenez un peu, toute ma toile à la fois, d'ensemble.” Gasquet, J. 1926. *Cézanne*. Paris, 89.

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COVER ILLUSTRATION and PLATE 8

Gherardo Cibo, "Colchico," folio 17r of *Herbarium*, ca. 1570. © British Library Board (ADD MS 22333).

PLATES 7a, 7b and PAGE 50, Figure 1

Valerio Mariani de Pesaro, *Battaglia di San Fabiano*, 1618-1620, GDSU. Images provided by permission of the Ministero per i Beni e le Attivita Culturali, Florence, Italy.

PLATE 12

Plate printed upside down in relation to Plate 11.

PLATE 17: (c. 50 x 246.5 x 2.5 cm)



PLATE 18: (c. 50 x 212 x 2.5 cm)



PLATE 29e

Plate printed upside down in relation to Plates 29a-d,f.

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Figure 3. Gherardo Cibo, "Hemionite," folio 143r of *Herbarium*, ca. 1570. © British Library Board (ADD MS 22333).

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Figure 4. Gherardo Cibo, "Fusaina [. . .] nocella qui chiamata a Roccha C[ontrada]," folio 183v of *Herbarium*, ca. 1570. © British Library Board (ADD MS 22332).

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Figure 5. Gherardo Cibo, several proofs of colors and “Fusaina” flowers, from folio 184v of *Herbarium*, ca. 1570. © British Library Board (ADD MS 22332).

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Paragraph 2. Alfred Butler assessed the beams in 1880, not the 1870s.

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Paragraph 4. The first icon, *The Virgin Mary and Child enthroned between Archangels, Prophets and Egyptian, Greek and Syrian Holy Bishops and Monks*, measures c. 50 x 246.5 x 2.5 cm, and is shown in Plate 17 and Figures 3 (left) and 4a, b. The second icon, *Six Equestrian Saints* (originally ten saints), measures c. 50 x 212 x 2.5 cm, is shown in Plate 18 and in Figures 2a,b; 3 (right); and 4c-e.

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Acknowledgments. The author...has been working since 1989 as the Field Director of the joint Egyptian-Netherlands ‘Coptic Icons Conservation Project’ based in the Coptic Museum in Cairo, not as the Field Director of the Coptic Museum in Cairo as originally published.

Note 3. The correct reference: Butler, A. J. 1884.

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Note 13. The correct reference: MacCoull, L.S.B. 1993. The Apa Apollos Monastery at Pharou. In *Le Muséon* (106), note 11.

Note 20. Abu al-Makarim, a Coptic priest from the church of the Holy Virgin at Harat Zuwayla, Cairo, left folios in a manuscript dating from around 1200 known as *History of the Churches and Monasteries in Lower Egypt in the 13th Century*. See Père Samuel du Monastère des Syriens. 1990. *Icônes et iconographie en Égypte au XIIe siècle d’après le manuscrit d’Abū- El-Makārim, publié en Arabe au Caire en 1984. Le Monde Copte, No. 18. Limoges, 78.*

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Figure 3. Mantegna, Andrea (1431-1506). *The Presentation in the Temple*. Original strainer with panel inserts seen from front. 68.9 x 86.3 cm. Gemaeldegalerie, Staatliche Museen, Berlin, Germany. Photo credit: bpk, Berlin/Art Resource, NY.

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Lines 9,12, and 14. “Mander” should read “van Mander.”

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Line 2. “No ground is used” should read “no ground appears in this sample.”

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Figure 1. Image source: Period photo reproduced in O. von Schleinitz, *William Holman Hunt* (Bielefeld and Leipzig: Verlag von Velhagen & Klasing, 1907).

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Figure 2. Image source: Period photo reproduced in O. von Schleinitz, *William Holman Hunt* (Bielefeld and Leipzig: Verlag von Velhagen & Klasing, 1907).

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Figure 5. William Holman Hunt, *Autoritratto*, Galleria degli Uffizi. Image provided by permission of the Ministero per i Beni e le Attivita Culturali, Florence, Italy.

Figure 6. Unknown Artist. Paint Bladder, 19th century. Oil paint contained in an animal bladder with three ivory plugs; 4.45 x 2.54 cm (1 3/4 x 1 in.) Harvard Art Museums/Fogg Museum, Straus Center for Conservation. Gift of C. Roberson and Co., London, FINV2155.

Photo: Imaging Department © President and Fellows of Harvard College

Brass paint tube, (not assigned). Harvard Art Museums/Fogg Museum, Straus.698

Photo: Imaging Department © President and Fellows of Harvard College

Empty paint tube, (not assigned). Harvard Art Museums/Fogg Museum, Straus.696

Photo: Imaging Department © President and Fellows of Harvard College

Figure 8. William Holman Hunt. *The Miracle of the Sacred Fire, Church of the Holy Sepulchre*, 1892-1899. Mixture of oil and resin on canvas; 92.1 x 125.7 cm (36 1/4 x 49 1/2 in.) Framed: 114.5 x 148.3 x 7 cm (45 1/16 x 58 3/8 x 2 3/4 in.) Harvard Art Museums/Fogg Museum, Gift of Grenville L. Winthrop, Class of 1886, 1942.198.

Photo: Imaging Department © President and Fellows of Harvard College

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Figure 3. *The Execution of Lady Jane Grey*. Pencil drawing for the central group, 18 X 16.5 cm. © The Trustees of the British Museum.

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Figure 2. J. M. W. Turner, *Dolbadern Castle, North Wales*, 1802. Oil on canvas, 1190 x 889 mm. Courtesy of the Royal Academy of Arts, London, www.racollection.org.uk.

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Figure 6. Detail of Anna's veil, painted over clouds and sky, from Joshua Reynolds's *The Death of Dido*, ca. 1781. Oil on canvas, 1473 X 2407. Supplied by Royal Collection Trust / © HM Queen Elizabeth II 2012.

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Figure 3. Brushes, paints, palettes, and other painting materials. © The Hunterian, University of Glasgow 2012.



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