J Forensic Sci, Mar. 2004, Vol. 49, No. 2
Paper ID JFS2003332
Available online at: www.astm.org

SPECIAL COMMUNICATION

David A. Stoney,[1] *Ph.D.*

A Selection of Some of Dr. McCrone's High and Low Profile Cases in the Forensic Analysis of Art*

ABSTRACT: Throughout Dr. McCrone's active professional career of over 60 years, he worked on many cases involving the forensic analysis of art. This is an overview of a small portion of these cases. Included (exposed as fakes) are the Shroud of Turin, the Vinland Map, Mayan pottery illustrations and Larionov pastels. Also included, with strong support for authentication, are three paintings attributed to Manet, Giorgione, and Leonardo da Vinci.

KEYWORDS: forensic science, forensic microscopy, Walter C. McCrone, art authentication, pigment microscopy, Shroud of Turin, Vinland Map, Manet, Giorgione, Leonardo da Vinci

The Shroud of Turin

Of all the cases Dr. McCrone worked on, the Shroud of Turin findings received the most publicity and provoked an intense, emotional response from many. The defense of his work on the Shroud took a lot out of Dr. McCrone during the years that I knew him. It was both a sounding board for his passionate defense of the Microscope and an excellent example of his character (1).

Long before Dr. McCrone became involved, there were two competing hypotheses concerning the Shroud. One, that it is the true burial cloth of Jesus Christ, and the other that it had been painted during the early 14th century.

Dr. McCrone examined tapings taken from the surface of the Shroud in September, 1978. His findings from a microscopical examination of these tapings were (1–6):

- That the tape samples were excellent and sufficient samples for microscopy
- That in the areas depicting the overall body image, the image was due to a highly-dilute, water-color type paint, made up of a collagen tempera medium and red ochre (a form of iron oxide) as the pigment
- That in the areas depicting images of blood stains, the image was also due to paint, but in these areas the paint included an additional, more intensely-colored red pigment: dry process vermilion (a form of mercuric sulfide)

The use of tape as a sampling tool is well established in the areas of forensic science, archeology, and art conservation. It is especially suitable to recovering surface fibers and residues present on fabric. The tapes were taken from 32 separate areas: 14 control (non-image) areas, 12 body-image areas, and 6 blood-image areas. Each of the tapes was covered with over a thousand fibers and those tapes from the image areas contained many fibers with adhering coloring matter, loose particle aggregates of coloring matter, and replications of linen fibers showing stripped, thin layers of coloring matter.

The presence of paint in the areas depicting the body image was established by identification of a paint pigment (red ochre) within a medium (collagen tempera). The red ochre was identified by light microscopy (intensely colored, orange-red, rounded, isotropic, high refractive index particles) and by scanning electron microscopy equipped with X-ray elemental mapping (detection of iron). The medium, containing the well-dispersed pigment, was observed directly and with protein-specific staining. Microchemical testing indicated the absence of disulfide bonding in this protein, providing strong evidence for collagen tempera, as the only protein-based medium without disulfide bonds.

The additional presence of dry process vermilion in the areas depicting the blood images was established by scanning electron microscopy equipped with elemental mapping (coincident mercury and sulfur), and by light microscopy (high index, red, rod-shaped particles). Dry process vermilion has a characteristic shape and color. It is made by fuming elemental mercury and sulfur, a hazardous process invented by alchemists about 700 A.D. This process was superceded with "wet process vermilion" (made by precipitation) in 1780.

The significance of these findings, in the context of the historical questions surrounding the Shroud of Turin, is (1) that they are conclusive evidence that the Shroud is a painting, and (2) that they strongly argue that the that the Shroud was painted between about 700 and 1780 A.D. Because the historical record of the Shroud begins with its first exhibition in 1356, it is a reasonable inference that it was painted contemporaneously.

It is noteworthy that methods of painting on linen, using thin, transparent water-color type paints, were widely practiced in Europe in the fourteenth century. It is also noteworthy that three expert carbon dating laboratories agreed (eight years after Dr. McCrone's work) on a date of 1325 $\pm$ 65 years.

[1] McCrone Research Institute, 2820 S. Michigan Avenue, Chicago, IL.

* Presented at the 55th Annual Meeting, American Academy of Forensic Sciences, Chicago, Illinois, Feb. 2003.

Received 7 May 2003; and in revised form 6 June 2003; accepted 18 Oct. 2003; published 19 Feb. 2004.

Put in the context of his career, Dr. McCrone's work on the Shroud of Turin was unremarkable. It was an intensely interesting subject, but not a novel application or novel result. What sets it apart in his career, really, is the reaction to his findings. For more than 20 years, Dr. McCrone's methods, results and objectivity were challenged among the lay public, the scientific community, and the pseudo-scientific community. When dealing with controversial issues, such criticism is to be expected, but that produced by the work on the Shroud was extreme and persistent, being quieted only slightly when the confirming results of carbon dating were announced eight years later. During this interval and after Dr. McCrone defended his work patiently, professionally and honestly while faced with a complex and frustrating combination of ignorance, slanderous pseudo-scientific criticism, and scientists using the methods of trace chemistry on this patently particle analysis problem. It was a very fitting and appropriate endorsement of his work when Dr. McCrone received the American Chemical Society's National Award in Analytical Chemistry in 2000 specifically for his application of analytical microscopical methods to the Shroud of Turin and for his patient, professional defense of these methods for more than 20 years.

The Vinland Map

Dr. McCrone's work on the Vinland Map (1972–3) (7) predates that on the Shroud of Turin and, in fact, the publicity surrounding the Vinland Map work had resulted in his invited participation in the Shroud of Turin Research Project.

The Vinland Map is drawn in black ink on parchment and was significant because it showed parts of North America (Vinland) and was reputed to have been drawn in 1440. Examination by Dr. McCrone, together with colleagues at McCrone Associates, showed that ink lines on the map had been meticulously forged, probably in the 1920s, to provide an appearance of extreme age.

The evidence was in the ink lines themselves. The colorless medium or vehicle of any black ink will, over a period of several hundred years, soak into the paper fibers and, with age, become yellow. This causes a boarder of yellowed parchment to surround a genuine, very old, ink line. To artificially achieve this effect the Vinland Map was, in fact, drawn twice: once with a broad yellow line, and secondly with a thin black line down the middle of all the yellow lines.

Twenty-nine samples of ink and parchment taken from the Map showed clear results: there was a separate layer of yellow ink under the black ink. This layer contained two pigments: titanium dioxide (in the anatase crystal structure) and yellow ochre. Anatase titanium dioxide, in pigment size and form, was invented in 1916. Its presence was confirmed by light microscopy, elemental analysis using scanning electron microscopy with energy dispersive spectroscopy, transmission electron microscopy, X-ray diffraction and ion/electron microprobes.

Titanium Dioxide: The Forger's Bane

In Dr. McCrone's work on forensic art analysis, the pigment titanium dioxide plays a central role in unambiguously demonstrating modern forgeries (8). A white pigment with good covering power was illusive for many years. An impure, yellow-tinted titanium dioxide (anatase) was first made as a pigment in 1916 and over the next decade, it was refined into a white pigment with excellent covering power. Rapidly coming into use, titanium white was further improved in 1940 when the rutile pigment form was first commercially prepared. The covering power of titanium white so greatly exceeds the alternative pigments that it is used today in almost all paints. This makes it hard for forgers, even those that are otherwise quite resourceful. Two examples out of many from Dr. McCrone's casework will illustrate the point.

Authentic Mayan pottery is valuable, but that with detailed illustrations depicting cultural and sexual practices among the Mayans is very valuable indeed. A museum curator, suspicious of the high volume of such wares procured from a single source, brought samples for examination by Dr. McCrone. The pottery itself was unquestionably old enough, as revealed by thermoluminescence, but (unfortunately for our understanding of Mayan practices) the illustrations all contained a very fine, extremely high refractive index white pigment, probed by X-ray analysis to confirm titanium dioxide.

More ambitious still was the project that apparently produced 1500 forged Larionov pastels (9). Larionov was a modern avant-garde Russian painter who left Russia in 1915 for Paris. His drawings are much sought after. In 1985, a trunk said to contain about 1500 Larionov pastels and drawings was discovered in Moscow and brought from Russia to Switzerland. Presumably, Larionov left these drawings in Moscow when he moved to Paris. This theory would depend on the paintings pre-dating his move. Unfortunately, during 1987 to 1989, Dr. McCrone analyzed 17 of these pastels, all showing titanium dioxide, and most showing a form and purity that was not achieved until 1957.

The Infanta (10)

The vast majority of questioned artwork examined by Dr. McCrone turned out to be forged. The jaded observer might well wonder, "Is anything genuine?" Among the few works passing the test, the most scientifically interesting is the Infanta.

There is a painting, *L'Infante Marie Marguerite*, which has hung in the Louvre since 1816 and that is believed to have been painted in 1654 by Diego de Velasquez (1599–1660). As is the practice among artists, many have registered to copy this painting and indeed, Edouard Manet himself registered to copy it in 1859 and completed the painting. The painting, however, has never been found and this "Lost Manet" has been the source of much interest and speculation over the years.

In 1967 a painting was purchased in Amsterdam that was brought out of post war Paris by a small collector-dealer. Based on Dr. McCrone's work (together with much additional stylistic and circumstantial evidence) this painting (referred to simply as the Infanta) is almost certainly the famous Lost Manet.

Almost always, the most "authentication" that can occur from a materials analysis of artwork it that the materials are consistent with the alleged date of production. In this case, the findings were both unusual and compelling. Dr. McCrone not only found pigments consistent with Manet authorship, he found highly individual pigment morphologies and chemistries that were also highly comparable to known Manet paintings. These known paintings were dated very closely to the Lost Manet (1860 and 1862, compared with 1859).

The pigments of most interest were lead white, cobalt blue and vermilion. Lead white usually forms rounded hexagonal plates. In the Infanta, as well as in samples from two known Manet paintings, the lead white was present in large, elongated prisms. Trace elemental analysis was also used to compare lead white prisms from the Infanta with those from one of the reference paintings. There was excellent agreement with all nine trace elements measured.

Cobalt blue, a glass composed of cobalt and aluminum oxides, is characteristically of refractive index greater than 1.66. This high index distinguishes it microscopically from other cobalt glasses

(notably smalt) that have a much lower refractive index (~1.54). In the Infanta, however, as well as in both of the reference Manet paintings, an unusually low refractive index cobalt blue pigment (confirmed by electron microprobe) was found.

In addition, the chemical analysis of vermilion found in both the Infanta and one of the reference paintings showed corresponding, unusually pure samples. The samples contained only mercury, sulfur and a trace of silicon.

The presence of a pallet including highly unusual pigments, together with excellent correspondence to the artist's known paintings from the same period, provides the best material evidence of authentication that one could ever expect.

Two Very Old Paintings: Giorgione and Leonardo

The more typical result is where the materials analysis provides evidence that shows the pigments are entirely consistent with authorship, but where the common nature of the pigments themselves, or the lack of the availability of comparison standards, prevent a stronger association. The analysis of two other paintings show this type of result, with strong, but not independently compelling support for authentication.

The first of these paintings is *Marcus Aurelius Between Philosophers* which is now recognized among art scholars as a newly found painting by Giorgione. Pigments from this painting, as well as samples from one known and one probable Giorgione, were analyzed and compared by Dr. McCrone (11). Analyses and comparisons were also conducted with paintings from four contemporaries: Leonardo, Michelangelo, Raphael and Correggio. The findings were typical for genuine very old paintings: older pigment types with strong indications of hand ground mineral pigments (coarse particle sizes and high levels of mineral impurities). Dr. McCrone's conclusion was, "The identity of the pigments, their particle size, the presence of mineral impurities and the absence of later common pigments make it most likely *Marcus Aurelius Between Philosophers* was painted during the very early 16th century or very late 15th century."

Based on style, chronology and iconography, a second painting, *Christ Among the Doctors*, is attributed Leonardo (12). Dr. McCrone's pigment analysis (again including comparisons with Italian contemporaries) also supported this assignment, "all of the materials present in *Christ Among the Doctors* were available at the time and in the places where Leonardo painted his few masterpieces."

Acknowledgments

Special thanks are due to Lucy McCrone for generous access to Dr. McCrone's records and papers and to the staff of McCrone Associates, whose work is described together with Dr. McCrone's for many of these cases.

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Additional information and reprint requests:
David A. Stoney, Director
McCrone Research Institute
2820 S. Michigan Ave.
Chicago IL 60616