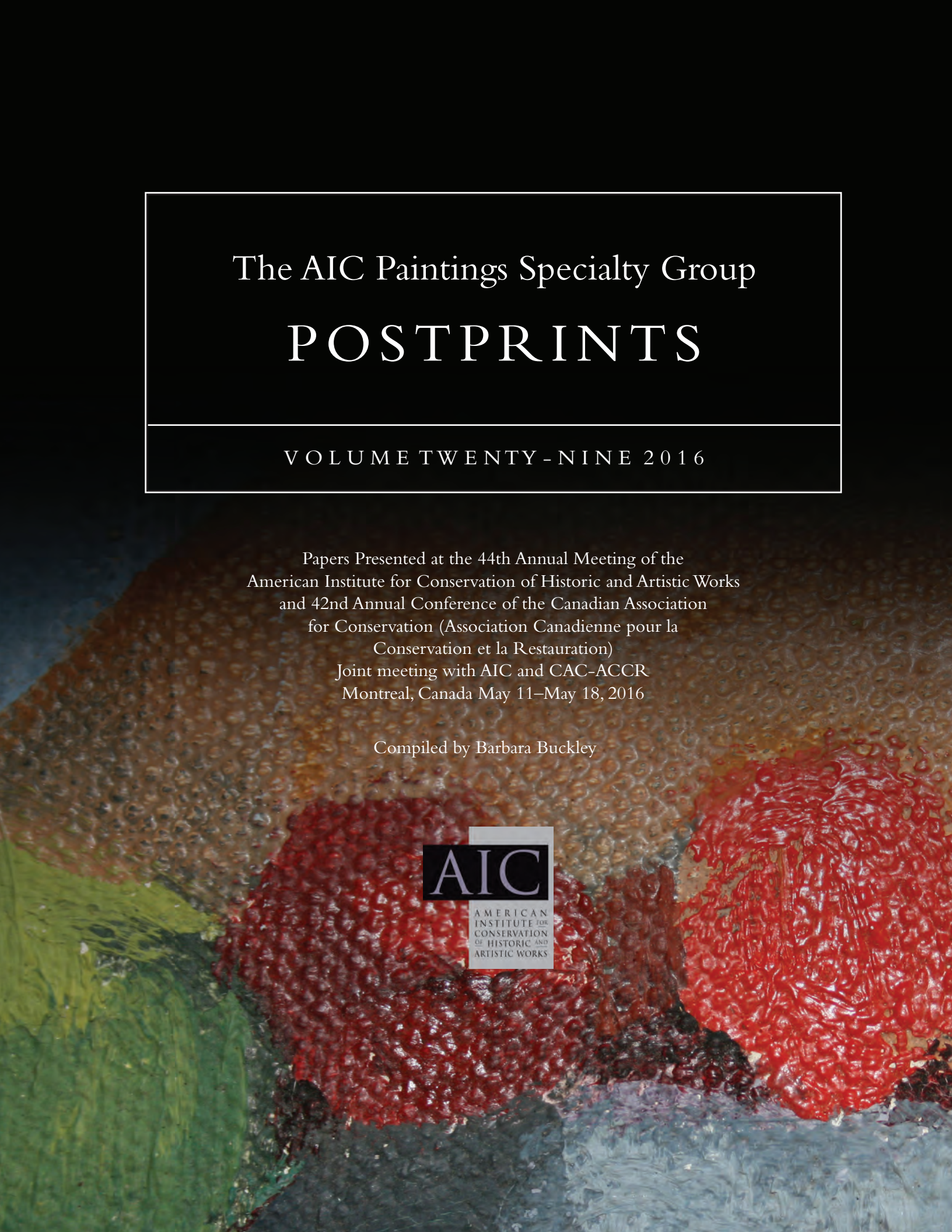
The AIC Paintings Specialty Group

POSTPRINTS

VOLUME TWENTY-NINE 2016

Papers Presented at the 44th Annual Meeting of the
American Institute for Conservation of Historic and Artistic Works
and 42nd Annual Conference of the Canadian Association
for Conservation (Association Canadienne pour la
Conservation et la Restauration)
Joint meeting with AIC and CAC-ACCR
Montreal, Canada May 11–May 18, 2016

Compiled by Barbara Buckley



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AIC PAINTINGS SPECIALTY GROUP

POSTPRINTS

VOLUME 29 2016 ANNUAL MEETING

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CAROLYN TOMKIEWICZ

The Aftermath of Hurricane Sandy: Rescue and Treatment

ABSTRACT

A united volunteer investment in recovery at the Westbeth Artists Housing is one story among many across New York City after the devastation caused by Hurricane Sandy in 2012. Innumerable works by artists living in this residence were affected by flooding of the basement that housed their workshops and storage spaces. American Institute for Conservation – Collections Emergency Response Team (AIC-CERT) volunteers, resident artists, and area conservators provided services to support the rescue efforts. Salvage activities undertaken by the author and responders are described. Three case studies further describe the efficacy and limitations of overall tensioning to lessen severe canvas deformations based upon the first of two stretching devices designed by Professor Winfried Heiber (Kluger, C. 1984/85).

Hurricane Sandy hit the Northeast coast of the U.S. on October 29, 2012 (fig. 1). Despite warnings, the severity of the Superstorm and its impact on New York City due to extensive flooding and power outages was hardly anticipated. Art objects did not escape these aftereffects, in particular water damage from flooding. Triage activity immediately following the event and treatment of water damaged objects were at the core of disaster recovery operations across the region. What follows is a personal recount of the rescue efforts at the historic Westbeth Artists Housing located in Lower Manhattan on 55 Bethune St. in close proximity to the Hudson River, followed by three case studies of treating severely water-damaged paintings.

Figure 1. Bundled in anticipation of Hurricane Sandy, the statue of St. Lucie fared well; October 30, 2012 one day after the storm, Carroll Gardens, Brooklyn, New York

On November 4, 2012, six days after the storm, the Foundation of the American Institute for Conservation of Historic and Artistic Works (FAIC) organized the Consortium on Recovery of Works of Art Damaged by Flooding for artists, collectors, conservators and the general public, hosted at the Museum of Modern Art, New York (MoMA).

Speakers from the American Institute for Conservation - Collections Emergency Response Team (AIC-CERT), now known as The National Heritage Responders along with MoMA conservators offered much-needed information on safely handling and drying wet artwork and cultural objects such as paintings, drawings, books, sculpture, and other materials. This meeting provided not only an opportunity for questions and answers, but also support for heart-wrenching stories told by artists who had lost their entire life's work.

The MoMA venue brought me in contact with a resident from the Westbeth Artists Housing. Lawrence Salemme described on-site conditions at Westbeth where the basement had been flooded with over 12 feet of water from the Hudson River purportedly tainted with detritus. This basement had served not only as workspace for artists but also storage space for

Figure 2. Dehumidification units staged in the courtyard for deployment in the Westbeth Artists Housing located in the West Village neighborhood of Manhattan, New York City

artwork. Transferred to Westbeth in July of 2012, The Martha Graham historic collection of sets, costumes, and artifacts—gathered over eight decades—was severely impacted.

After building safety issues had been reviewed, more than 10 days after the storm had struck, artists were allowed entry to the dark, wet basement. Management had immediately organized pumping out water as well as installing dehumidification units (fig. 2). Mold growth was already a major problem.

Lawrence had innumerable questions concerning paintings, drawings and sketchbooks by the late artist John Dobbs whose widow Anne had given Lawrence *carte blanche* to do whatever it took to care for John's artwork. There was no simple answer. It was an overwhelming situation with which I had never before been directly confronted nor could I imagine the extent of damage. It was clear that heading over to the Westbeth Artists Housing with supplies was the only option. My only advice to Lawrence was: "rent a large van and start moving paintings and works on paper out of the basement to the courtyard." This was New York City. Anything left outside might not be there the next morning, so the van was used for overnight storage. Unfortunately for many artists things left outside to dry disappeared.

What supplies does one have on hand that might be useful for this unknown? A lab coat, Nitrile gloves, N95 particle masks (appropriate protection against mold spores), 70% isopropyl alcohol, atomizers, paper towels, Scott toilet tissue, a stock solution of 10% Aquazol 200 in isopropyl alcohol, a Miele HEPA vacuum, skewer sticks, cotton, and last but not least Wee-Wee Pads. Needless to say, we used hundreds of these super absorbent, plastic coated pads (fig. 3a, b).

Figure 3a. Supplies included a lab coat, Nitrile gloves, N95 particle masks (appropriate protection against mold spores), 70% isopropyl alcohol, atomizers, paper towels, Scott toilet tissue, a stock solution of 10% Aquazol 200 in isopropyl alcohol, a MIELE HEPA vacuum, skewer sticks, and cotton

Figure 3b. Wee-Wee Pads are absorbent pads found in most pet stores

Responding to an emergency call from the Martha Graham Collection, AIC-CERT advisors were already on the scene at Westbeth to offer help and advice to more and more artists who joined Lawrence in efforts to rescue their works from the basement. Initially, paintings were laid out in the courtyard face-up on blocks for air circulation. Due to mold growth on frames, canvases, and stretchers, paintings were placed face in to the courtyard wall. 70% isopropyl alcohol was atomized onto the verso of both canvases and frames and allowed to dry (fig. 4a, b).

Lawrence purchased all available door screening material from nearby Home Depot in order to fabricate drying stations. Using wood slats to attach the screening between two folding tables and a second screen as a cover, works on paper could be laid out to dry without being blown away. The winds were brisk, the air was cold and the sunshine was limited. Volunteers were sent off to buy clothesline to dry negatives, more rubbing alcohol, more plain paper towels and wax paper as interleaving materials for drying pages of the John Dobbs sketchbooks and other works on paper (fig. 5a, b).

Figure 4a. Westbeth Artists Housing courtyard, November 10–18, 2012

Figure 4b. Westbeth resident, Lawrence Salemme, leaning paintings against wall with the painted side of the canvas facing inward

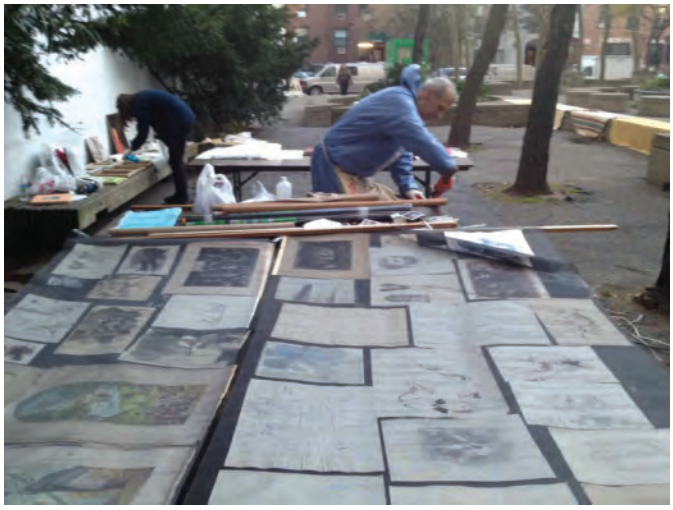

Figure 5a. To prevent the drying works on paper from being blown away in the wind they were sandwiched between suspended layers of door screen

Figure 5b. Plain paper towels and wax paper were used for interleaving the wet pages of John Dobbs sketchbooks

Both AIC and TALAS sent donations of sorely needed supplies, such as blotting paper and ethanol. Hazmat suits, gloves, and particle masks were made available through AIC. Karen Yager, Chris Stavroudis, Vicki Lee, Hitoshi Kimura and many others from the AIC-CERT team were on hand to advise and help in varying capacities instructing artists on how to salvage what could be salvaged. Throughout the week, from early in the morning until very late at night more artists and more artwork appeared in the courtyard. New York-based conservators of paintings, paper and objects volunteered alongside professionals from the AIC-CERT team focused on the Martha Graham rescue efforts. While taking a break from the mold-infested basement, AIC-CERT volunteers pitched in to assist all artists emerging onto the courtyard with sculpture, porcelain, glass, photographs, negatives, paintings and drawings (fig. 6a, b).

One such example involves pieces from a conceptual installation by Judite dos Santos. The artist comments: "The News stacks were made from newspapers, tied with cord, electrical or metal wires, and painted with white acrylic. There are a number of intended metaphors, which include containment of the body; censorship, manipulation and standardization of information through the process of packaging and 'white wash'; memory loss and systems of social control." According to the artist, 70 bundles survived from the original installation. Our efforts included placing the bundles on end, separating these waterlogged bundles with sections of cut cylinders left over from all the wax paper rolls that served to interleave photographs. The cardboard cylinder held up well and kept the bundles separated for air circulation (fig. 7).

Figure 6a. AIC-CERT Conservator and Lawrence Salemme washing and drying photographs

Figure 6b. Conservator, Sara Levin, using absorbent tissue for interleaving paper on the fabricated drying screens

Colleagues were called and colleagues came to lend a hand in moving objects to the courtyard for drying, washing photographs and setting them out to dry on Wee-Wee Pads, and washing negatives and hanging them out on the clothesline that was strung between the trees. It seemed makeshift, but the sense of saving what we could encouraged us to go on—day in and day out.

There was such enormous destruction that an effort was made to salvage not only personal artwork but personal possessions like family photographs—contemporary, of 20 years past, and of previous generations. Everything was personal—everything was important, and we endeavored to save whatever we could. The massive quantity of material and the piles did not allow for serious prioritizing in most cases. Possessions considered of lesser importance to the residents/ artists were put aside for later handling or discarding.

At the end of the day, unfinished work from the collection of John Dobbs paintings was carried into the rental van that could be locked. Left without an alternative, many works were

Figure 7. Hundreds of pounds of bound and painted newsprint, by conceptual artist and sculptor Maria Judite dos Santos, were placed on end as they dried, and, for air-circulation were separated by cardboard tubes recycled from wax paper rolls

left outside and covered with tarps in hopes that they would still be there the next morning, including beautiful tapestries by Susan Berger who attended the meeting at MoMA. As soon as management allowed entry into the basement, Susan moved her collection of tapestries to the courtyard for drying and treating (fig. 8).

Figure 8. Tapestries by Sue Berger air-drying in the courtyard of Westbeth Artists Housing

Figure 9. Conservator, Caitlin Breare, facing a painting with rolled tissue and a facing adhesive of 3% Aquazol 200 solubilized in a 1:2 mixture of water and isopropyl alcohol

The painted surfaces were examined for lifting due to water-induced contraction of the fabric. Based on previous experience 3% Aquazol 200 solubilized in a 1:2 mixture of water and isopropyl alcohol served well as a facing adhesive. The risk of paint or resin sensitivity to either solvent alone is greatly reduced or eliminated. Aquazol is compatible with other adhesives such as animal glue or BEVA-371 should the decision for these adhesive options be made later during the treatment phase. For the degree of tenting, Scott toilet tissue as a facing material conformed well, was easy to section off, and easy to apply (fig. 9).

Once dry, the paintings were unframed so that the rabbet of the frame as well as the outer perimeter of the canvas could be treated with a spray of 70% isopropyl alcohol. Management was persuaded that the Community Room be opened for continuing work. The reframed paintings were moved into the residence Community Room for vacuuming at the end of the day. The pages of dried sketchbooks were interleaved with silicone release paper, which was left in place. The books were then packed for storage with acid-free rag board covers, tied with twine and labeled. Work continued throughout the week and into the Thanksgiving holiday. Plans were made to move recovered artwork to off-site storage in New Jersey.

In late December, 2012, FAIC announced the opening of the Cultural Recovery Center (CRC) in Brooklyn (fig. 10a, b). Volunteer assistance and workspace was offered to museums, libraries, archives, historic sites, galleries, collectors and artists. From the end of December 2012 through the beginning of

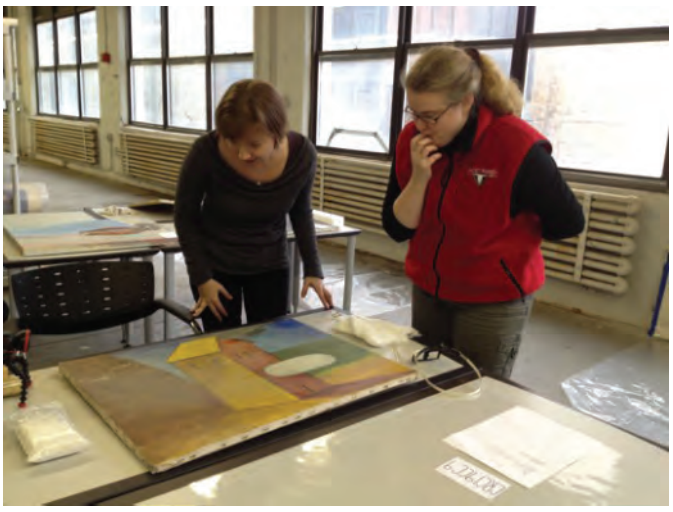

Figure 10a, b. FAIC sponsored Cultural Recovery Center (CRC), Brooklyn, NY. Space, tools, and supplies allowed for examination, documentation, remedial treatment, and packing of artwork

March 2013, the CRC at Busch Terminal reached out to the Conservation Community in search of volunteers to assist AIC-CERT team leaders. The goal was to provide guidance and assistance in the stabilization of art and cultural materials. Systematic documentation of all works was carried out. An enormous chamber was available for spraying alcohol against mold growth. Artists and collectors were assisted in surface cleaning and packing artworks.

During the final four days at the recovery center in March 2013, I again met Jayne Holsinger from the Westbeth Artists Housing. Jayne was trying desperately to flatten severe deformations in her oil on canvas painting *River* (66 × 65 ¼ in.).

Jayne described entering the basement of Westbeth once access was allowed and seeing *River* rolled over an inner tube contained in an outer PVC tube. Not hermetically sealed, the painting had gotten partially wet. After hearing that the invading waters were likely contaminated, the artist washed the affected wet areas in the bathtub and allowed the canvas to dry. Thereafter, she made an attempt to stretch the canvas and locally spray with water to flatten the deformations. As Jayne described these efforts that failed, it soon became clear that the painting should be professionally treated (see Case Study 1).

The construction of a tensioning device with the help of Simon Liu was prompted by a severely water damaged painting by Max Ginsburg, not six months prior to Hurricane Sandy (fig. 11). The outcome was published in the WAAC Newsletter (see Tomkiewicz, C., (2013)) in hopes of making this technique available for fellow conservators dealing with similar water damaged paintings. This device is modeled after an original system created by Professor Winfried Heiber as early as 1984 in Bedburg, Northern Germany. The original system is based on wood blocks that firmly clamp onto the tacking margins of the painting at regular intervals.

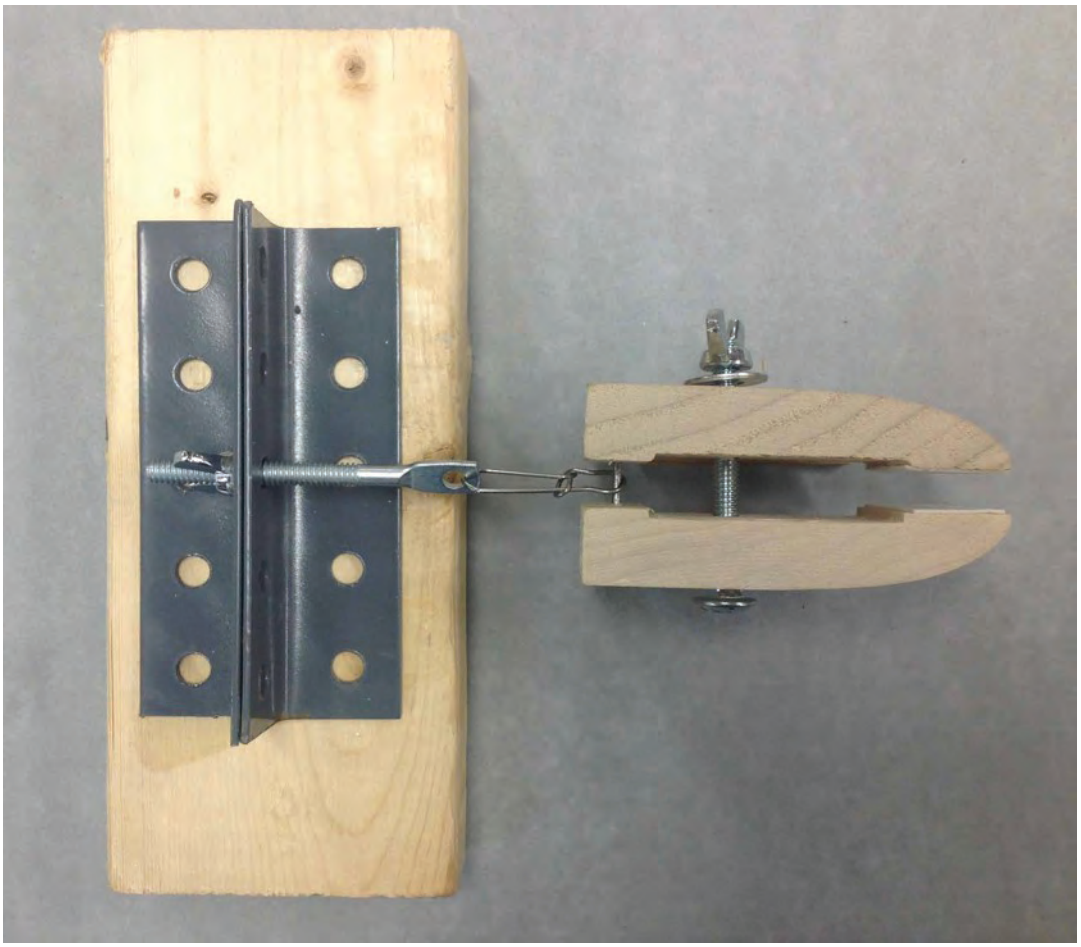

Figure 11. Wood clamp is attached to a strainer to adjust tension on the canvas (WAAC Newsletter, Volume 35, Number 2, May 2013, pp. 18-20)

The turnover edges can be extended if the painting permits or can be clamped at right angles. Originally, webbing straps extending from the wood blocks were pulled to the strainer and stapled. Pulling is incremental as the staples can easily be pulled out and re-stapled. The webbing straps can be secured to a Rigamonti stretcher with incremental corner expansion capability. Winfried Heiber influenced the conservation profession by disseminating his creative solutions through interns fortunate to have been able to work with the "Master" as Claudia Kluger who published this technique in 1984/85 (see Kluger, C., (1984/1985)).

A precursor of the wood clamp system is the "Dutch Method." In 1989, a graduate student from the Akademie Stuttgart implemented the concept of pulling out severely contracted canvas under my guidance at the Brooklyn Museum of Art. The turnover edges were faced with wet strength tissue and gelatin. The painting was infused from the verso (face up) with a solution of BEVA-371 diluted with petroleum distillate and warmed to approximately 70 degrees C. Sized cotton muslin was adhered with BEVA-film to the recto and verso, thus sandwiching the tacking margins. The "edge lining sandwich" was attached to a work strainer. The deformed but stretched canvas was placed face up approximately 2 inches above blotters wetted with saturated sodium chloride (NaCl), with Mylar covering the perimeter to create a humidity chamber beneath the canvas. The paint and ground layers provided an adequate barrier such that the surface was not covered when establishing the humidity chamber and the surface could thus be monitored. The deformations were slowly adjusted out over a period of several days by differential tensioning as needed and securing with pushpins.

The tenting was so severe that further local expansion was needed to allow the edges of the cracking paint to abut when consolidated. This was achieved with a rather simple heating tool: a light bulb, a gooseneck clamp socket, a watch glass, and a dimmer switch (fig. 12). The watch glass was placed on the light bulb for an appropriate convex slope to expand the canvas locally along the tenting. A 100-Watt bulb on a dimmer could be scrolled down to 70 degrees to reactivate the BEVA-371 infusion. The dimmer could then be scrolled down further so that the tenting could be pressed into place with flake edges abutted gently pressed with a silicone shaper. This so-called "burnt finger" technique left convex protuberances across the surface where the canvas had severely contracted. Once again, a humidity chamber was created with 74% relative humidity (RH) beneath the canvas. The result was absolute planarity across the entire surface by the following morning.

Professor Heiber further developed overall tensioning with the "Gleitholzrahmen" (see Heiber, W. (2006)). The described temporary stretcher is a construction to stretch and to humidify

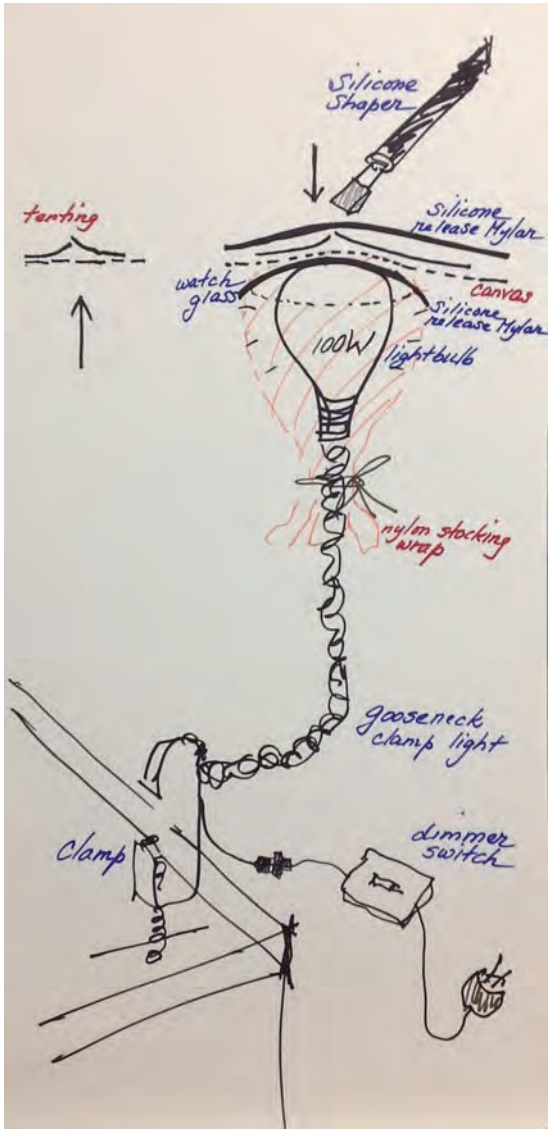

Figure 12. Heating tool to facilitate the "burnt finger" technique used for the consolidation of tented paint layers

the entire painting, preserving the turnover point of the edge of the painting in the right-angled form instead of flattening them in the methods described in these case studies. The tacking points are mobile. This is facilitated by the tacking margin mounted on short wooden bars, which slide in rigid L-shaped aluminum bars along the perimeter in all directions around the four edges. The aluminum bars are mounted on a Lascaux-Stretcher. By the mechanism of mobile mounting points the deformed edges of a painting can be stretched including the turnover point and the tacking margin. Screws on each side of the corners serve to open and to enlarge the stretcher (keying out).

Three case studies are described below of paintings that were treated with the tensioning device that takes Professor Heiber's concept into a direction of mechanical ease with differential, incremental stretching.

CASE STUDY 1: *River* By Jayne Holsinger

The water damaged painting *River* by Jayne Holsinger (fig. 13) was removed from its stretcher. Thereafter, the clamps were attached to the centers and corners. The attachment of the clamps to the "L" angles screwed to the strainer via threaded bolts allows for ease in tightening by turning on wing nuts to increase tension, instead of re-stapling or repositioning pushpins. Many variations were tested including the fabrication of loops of Surflon® wire to connect the wood blocks and the threaded bolts. These wires must be held whilst tightening to prevent twisting. Therefore these wires were replaced with duo-lock snap fishhooks that will not twist. Once placed in the stretching device, a humidity chamber beneath the painting was created (fig. 14a, b, c).

The humidity chamber was maintained at 74% RH by flooding thick blotter with a saturated solution of NaCl. Plastic sheeting beneath the painting and plastic sheeting over the clamps maintained this elevated RH that was monitored on all sides with humidity paper indicators with colored support. These are easy to use and read. Dial hygrometers can also be used for more precise reading. Within seven days, the planarity of the canvas was appreciably improved.

Figure 13. Before treatment. Jayne Holsinger, *River*, 2012, oil on canvas, 66 × 66 in.

Figure 14a. During treatment. Clamping is begun at the corners and center edges of the canvas

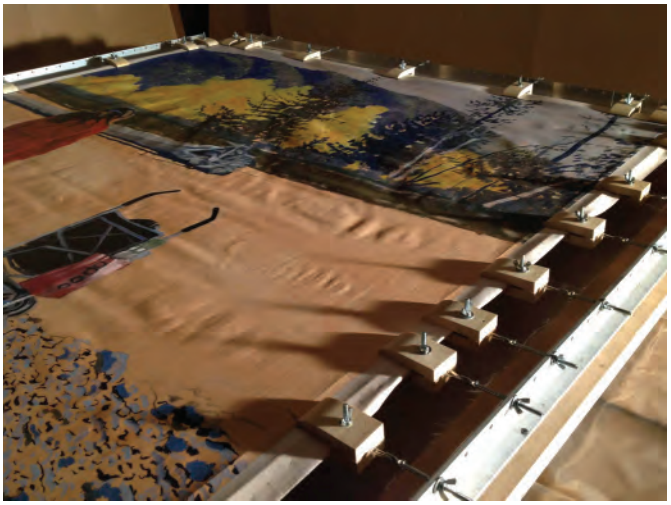

Figure 14b. During treatment. Clamping of *River* after seven days at 70% RH

Figure 14c. The painting is clamped to incrementally tension the canvas while exposed to elevated 74% RH beneath

Figure 15. After treatment. Jayne Holsinger, *River*, 2012, oil on canvas, 66 × 66 in.

In raking light, residual deformation was noted and the final treatment was carried out on the low-pressure suction table. Some horizontal, blind, micro-tenting was noted. Only areas of open tenting were treated with 3% sturgeon glue using isopropyl alcohol as a wetting agent. In general, the blind tenting appeared stable and could not be reasonably treated for absolute flattening, so was left (fig. 15).

CASE STUDY 2: John Barnes Dobbs, American painter (1931–2011)

A painting by John Dobbs painted around 1960 was also treated following Hurricane Sandy. Pulled from the wet basement at Westbeth, the painting was brought to the courtyard for drying (fig. 16). The verso was treated with isopropyl

Figure 16. Painting by John Dobbs in the basement of Westbeth Artists Housing: wet with mold growth

alcohol against mold growth and the severe tenting was faced with tissue and 3% Aquazol 200 in water/alcohol (1:2).

The canvas was not as malleable as the canvas of *River*. It was stiff and difficult to expand even with the aid of this tensioning device. The canvas was impregnated from the verso with BEVA-371 in petroleum benzine. Humidification was carried out as described in Case 1 with saturated NaCl on blotter beneath the painting within a chamber.

The "burnt finger" technique was utilized to help flatten the severe tenting. The paint showed little flexibility and there was a limit to the amount of flattening that could be achieved. Nonetheless, access to the verso while the canvas was under tension facilitated the treatment (fig. 17). The residual deformations were treated on the low-pressure suction table with hot spatula heating through silicone rubber pads through the face. The end result of the treatment was acceptable. The bottom edge of the painting that could not be stretched to the outer perimeter of the stretcher was inpainted and is not visually disturbing (fig. 18).

Figure 17. Water-damaged painting by John Dobbs on tensioning stretcher

Figure 18. After treatment. John Dobbs (1931–2011), unidentified painting, c. 1960

CASE STUDY 3: *War Pieta* by Max Ginsberg

This stretching device was originally constructed in order to treat the painting *War Pieta* by Max Ginsburg, damaged by flooding from roof leakage in the artist's studio (fig. 19). The concept of re-tensioning across the whole under conditions of controlled elevated humidity levels resulted in recovering the planarity of the severe deformations (fig. 20a, b).

The undulations were successfully eliminated. However, the very tight, blind tenting in areas of direct water exposure remained. Isolated areas of flaking were consolidated, filled, and inpainted locally. After long contemplation, the decision was made to infuse BEVA-371 in petroleum distillate through the verso and reactivated on the low-pressure suction table with heat through the face through silicone rubber pads (figs. 21–22).

Figure 19. Before treatment. Max Ginsburg, *War Pieta*, 2007, oil on canvas, ca. 60 × 50 in.

Figure 20a. During treatment. Process of clamping the tacking margins to prepare for incremental tensioning

Figure 20b. During treatment. Clamping and tensioning under RH conditions elevated to 74% with saturated NaCl

Figure 21. During treatment. Low-pressure suction and heat applied to the face of the painting were used to reactivate BEVA-371 during the treatment of *War Pieta*

Figure 22. After treatment. Max Ginsburg, *War Pieta*, 2007, oil on canvas, ca. 60 × 50 in.

CONCLUSION

The devastating aftermath of Hurricane Sandy tested many. Dealing with cases of damaged artworks required speed, innovation, and resolve. The generosity, camaraderie, and support demonstrated by those involved was essential to the survival of artworks as well as spirits. Water damaged canvas paintings are complex to treat, but the development over the years of Heiber's tensioning device has resulted in several successful cases.

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MORWENNA BLEWETT, LYNNE HARRISON, and DAVID PEGGIE

Preparing for the Worst: Re-Developing and Tailoring a Rapid Response 'Grab Bag' and Procedure to the Specific Needs and Limitations of the National Gallery, London★

ABSTRACT

Responding to an attack on a painting requires input from both scientific and conservation personnel. A well-developed knowledge of the collection, its building, and staffing is also essential. This paper discusses the nature of attacks on paintings and previous research into response procedures. The primary focus is the redevelopment of the incident response grab bag for the National Gallery, London, which caters for various types of attack. Discussions center on developing the contents of the new bag through materials testing. This research established a response procedure and a programme of maintenance for the bag.

1. INTRODUCTION

In the aftermath of a corrosive attack on a painting, the conservator can significantly reduce the damage sustained if expedient action is taken. Unlike a graffiti or knife attack, a corrosive one extends beyond the point of execution with damage increasing over a short period. While the conservator needs to take action, well-meaning but ill-informed intervention can, in some instances, serve only to exacerbate the damage.

Archival records show that most incidents of vandalism at the National Gallery (NG) have involved mechanical damage meted out with, or without tools. Since 1863, these occasions have caused damage to 15 works of art and have included the use of knives, a hammer, a meat cleaver, razor, fist, and a gun. There have been three incidents involving the imparting of a noncorrosive substance on four works. These have featured two acrylic paint–based events and one lipstick impression.[1] There have been no incidents involving corrosive agents.

More recently, in 2011, two further works were vandalized in a spray paint attack.[2] Consequently the NG's emergency grab bag and response procedure was reviewed and updated. It was felt that better provision for dealing with three different sorts of attack—mechanical, noncorrosive, and corrosive—could be made. While the equipment and procedures for approaching mechanical and noncorrosive attacks will be discussed briefly in this article, the major part is devoted to the development of a newly equipped grab bag and response procedure for dealing with corrosive attacks on paintings. The bag and response procedure have since been used in three incidents to date.

2. PREVIOUS MEASURES

The gallery previously used a smaller and more limited kit, which was aimed at addressing corrosive attacks only. The rationale behind this approach was that such an event is gravely serious, and the damage is ongoing from the point of execution (fig.1). A corrosive attack demands immediate assessment and possible expedient action; however, the effects and aftermath of other types of attack are somewhat more static and can be arrested and contained. Other emergency-response materials were included in the previous procedure. These focused on salvage and protection rather than vandalism, for example, methods for protecting against water ingress and fire.

For a more detailed discussion of the research and testing that went into the practical procedure the NG now uses, see the authors' recently published article in *Studies in Conservation* and the NG's online resource, the details of which are at the end of this article (Blewett, Harrison, and Peggie 2015).

★ This paper was previously published in a different form in *Studies in Conservation*, 2015.

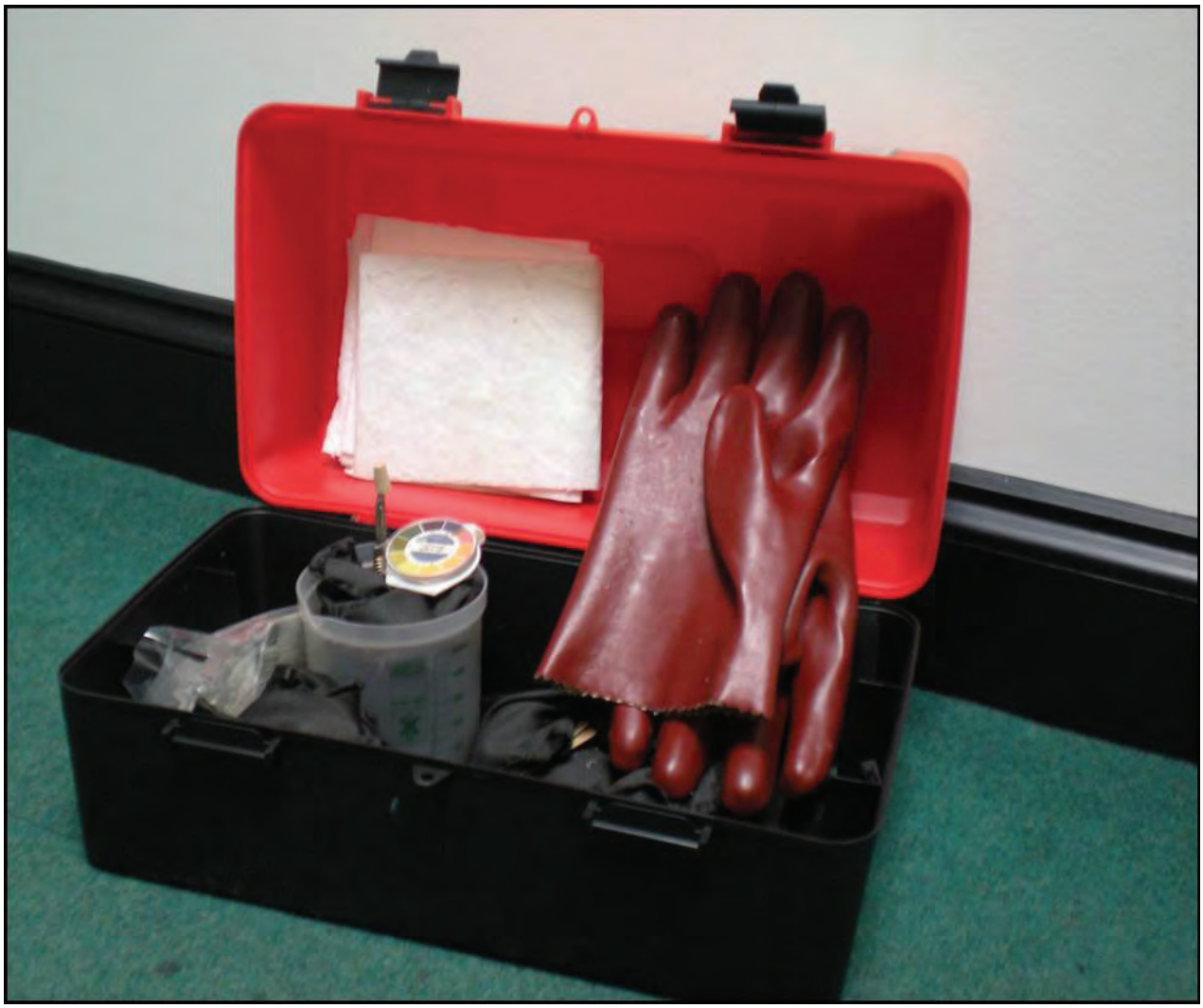

Figure 1. Old National Gallery response kit

3. BACKGROUND

A number of acid attacks on paintings in European galleries were reported in the 1970s and 80s. The painting *Archduke Albert of Austria* by Rubens in the Gemäldegalerie, Dusseldorf, was drenched in sulfuric acid, with many splashes and drips that ran the length of the portrait reaching the frame rebate. It suffered severe damage, although the thick natural resin varnish on the surface of the paint retarded the acid's action (Peter 1978).

Five panel paintings by Durer at the Alte Pinakothek in Munich were also attacked: *The Lamentation of Christ, Mary Mother of Sorrows, and The Paumgartner Altar triptych*. The gallery had an emergency plan, including a disaster kit and protocol that meant the paintings were treated quickly, reducing the damage inflicted. However, the response team did not remove the paintings from their frames, and the acid pooled beneath the frame rebate severely damaging the panel supports (Heimberg 1990, pers. comm.).

Some institutions responded to the attacks by spraying water onto the paintings' surface. After a relatively small-scale attack on Rembrandt's *Nightwatch* in the Rijksmuseum, Amsterdam, specially trained staff sprayed high volumes of water on the acid-targeted area, successfully washing the acid from the surface (fig. 2). The extremely hydrophobic structure of the *Nightwatch*, with its heavy wax lining and thick dammar varnish, meant the painting withstood the response; in fact, this remains the chosen response for such attacks at the Rijksmuseum (van de Laar 1994, pers. comm.; de Riddler 2013). In 1988

Figure 2. *Night Watch*, Rembrandt, Rijksmuseum, Amsterdam; attacked with sulfuric acid in 1989

water was used in response to a devastating attack on Rembrandt's *Danae* in the Hermitage, St Petersburg. The addition of water, however, greatly exacerbated the damage inflicted (Norman 1997).

The outcomes of these acid attacks indicated that the degree of damage inflicted by the chemical (and water if used in response) is essentially determined by two factors: the level of preparedness of the institution and the physical structure of the targeted painting.

4. EARLY RESEARCH

At the Courtauld Institute of Art, London, in the early 1990s, Alan Phenix and Lynne Harrison investigated the extent of damage inflicted by corrosive agents on paintings, and the effect of different immediate recovery responses (Harrison 1995). A kit and protocol specifically for the Courtauld Collection was designed as a result of the findings. Particular areas of this research pertinent to the National Gallery collection, and the recent updating of the response kit and procedure are discussed subsequently.

5. TESTING AND RESULTS

Extensive empirical testing of a range of corrosive agents (most readily available to the general public) was conducted on a number of test paintings representative of the Courtauld Gallery collection. The range of agents reflected a balance of generic properties and encompassed as wide a range of chemical action as possible. Testing highlighted the possible magnitude of damage inflicted on a painting, as well as the health and safety concerns for those involved in the recovery. Various real-life physical responses were trialed. These included allowing time to pass before removing the agent, changing the orientation of the test painting, applying water, attempting dry removal, and encouraging evaporation of the agent.

It was clear that every corrosive agent tested was capable of producing extensive damage to the majority of the painting types. As anticipated, the most destructive agents were the acids. Their action was immediate, acute, and ongoing, penetrating through the full thickness of every test painting at every point of contamination, whether by dripping down a vertical surface or pooling on a horizontal one. Even the smallest quantity caused significant damage (fig. 3).

The alkaline agents also proved very harmful, causing increased damage with prolonged exposure, for example, being allowed to pool on a horizontal surface. In some instances, however, these agents evaporated before reaching the bottom of the sample. The solvent-based paint stripper,

Figure 3. Nitric acid on chalk ground sample fizzed and bubbled as CO_2 was released

as expected, swelled and softened all the oil and resin layers it touched. A bleaching agent (sodium hypochlorite) inflicted a surprising amount of damage on all test paintings, soaking structures, dissolving layers, and inducing pigment color change (fig. 4).

An aged and degraded oil painting sample was badly damaged by the acids, while the same sample, heavily impregnated with wax showed a significant increase in time taken for the corrosive agents to inflict damage. Test paintings sensitive to water were badly spoiled by every agent tested and were further damaged by the subsequent addition of water. In fact, the addition of water exacerbated the damage in almost every test scenario. Water spread the agents and disrupted paint layers further. The only exception to this was the wax-impregnated oil painting sample, which showed minimal increased damage.

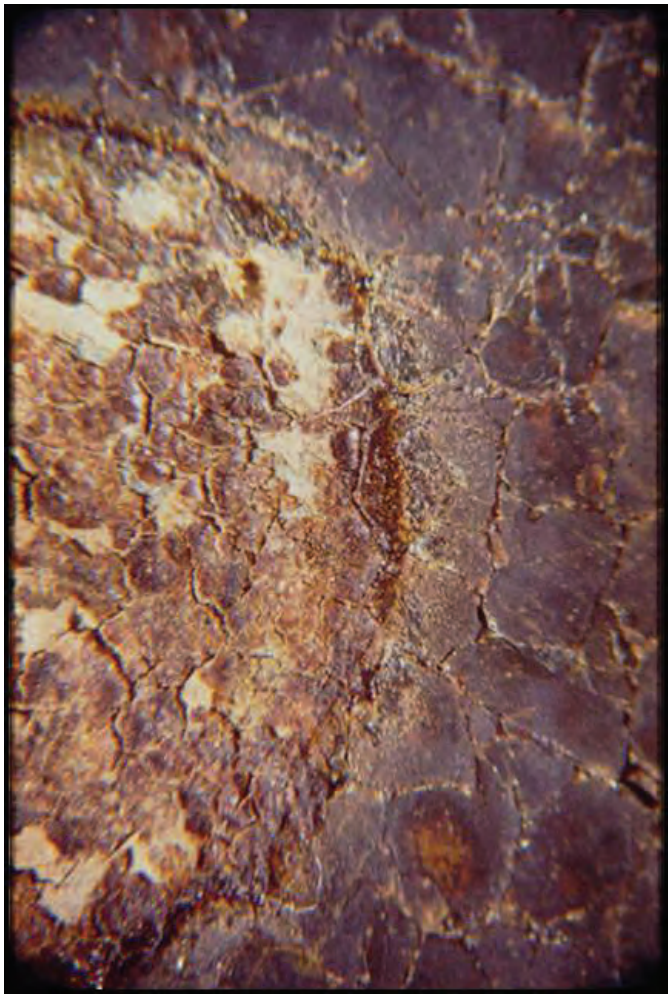

Figure 4. Damage caused by pooling on the surface of 18th century oil on canvas sample

Figure 5. Courtauld Gallery response kit

6. COURTAULD GALLERY RESPONSE KIT

As a result of testing, a specific response kit and procedure was developed for the Courtauld Collection (fig. 5). The corrosive agents were grouped by their characteristics and, more importantly, by their action on each painting type, into three groups—acids, alkalis, and neutral pH substances. Flowcharts were designed for use with specific equipment and materials provided in a portable response kit. The flowcharts take the operator through a series of simple, precise steps acting directly on the targeted painting (fig. 6).

7. NATIONAL GALLERY GRAB BAG RATIONALE

The conservators determined that the diagnostic and cleanup approach using the flowchart guidelines developed for the Courtauld Institute of Art disaster kit would be suitable for NG use. The new NG grab bag was also designed to include equipment to address any malicious damage caused by mechanical means, or those attacks featuring noncorrosive substances.

Discussions took place regarding the staff who would be involved in the response to an attack, corrosive or otherwise. Other institutions have trained their security staff to take an independent role in emergency first response, like that of the

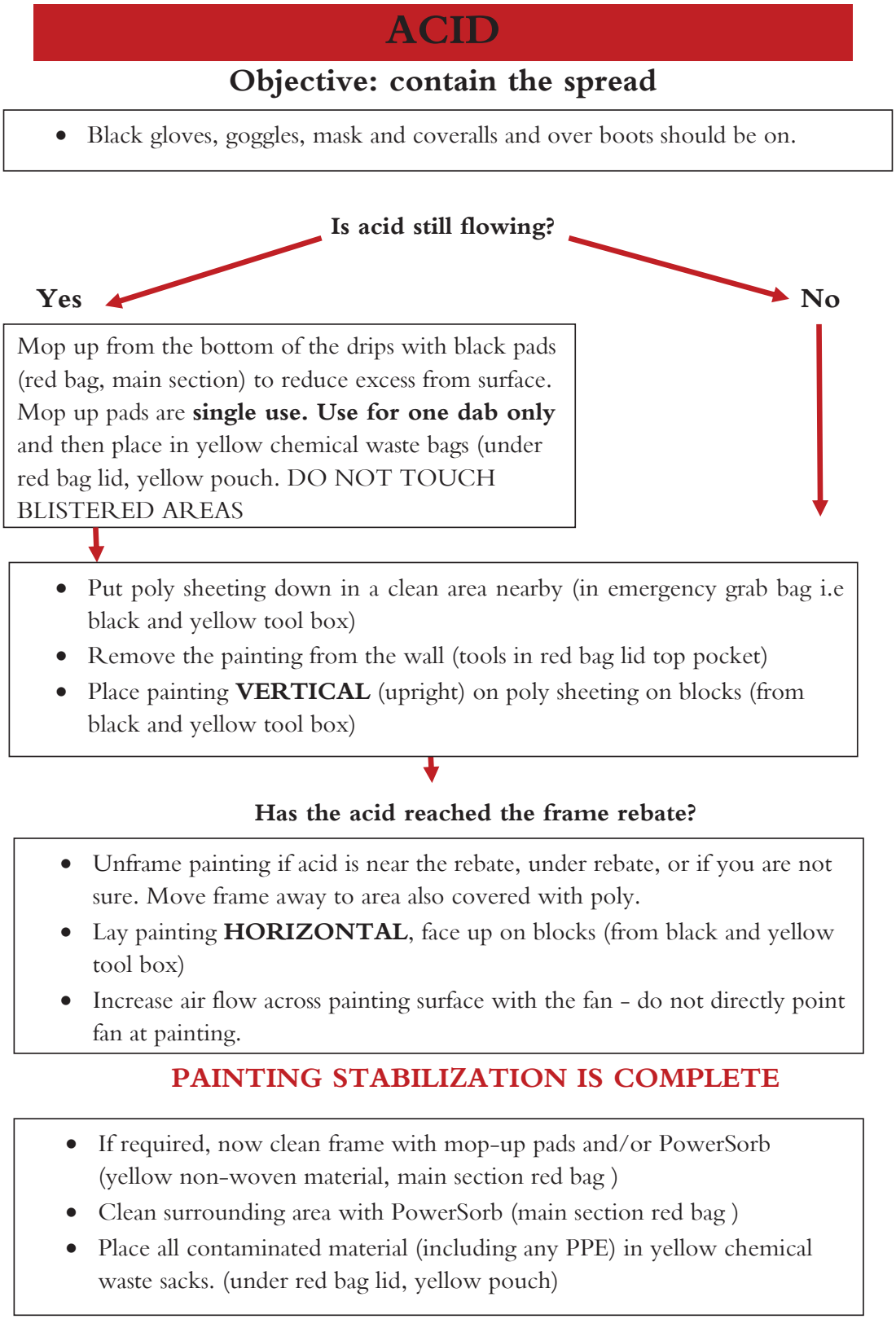

Figure 6. Flow chart

Rijksmuseum. However, only NG conservation staff are trained to lead a response using the NG grab bag. It contains specific materials and equipment for use on and around the paintings for response to any malicious attack, so it is necessary for the user to have specialist conservation knowledge to implement it effectively. Unlike the Rijksmuseum, which has paintings of similar materials and conservation history grouped together, the requirements and responses of National Gallery works are diverse in each gallery space. Managing quickly evolving health and safety issues would have been more difficult had other types of staff been involved and contractual issues and job specifications been also problematic. Adopting a conservation only response to attacks is made somewhat easier at the NG as the conservation department is in close proximity to the galleries, which allows for quick response by conservation staff during the week. This, of course, is not the case on weekends. Similarly, for many other institutions and museums, security staff are likely to be the first on the scene, perhaps for some time before conservators are summoned. Gallery staff could assist under the direction of the instructing conservator if requested.

8. BAG AND CONTENTS

A bag designed for paramedic use was chosen (fig. 7). This has the capacity to house all the equipment and personal protective equipment (PPE) to address all three types of attack (e.g., coveralls, eye protection, and different respirators). Evaporation-proof bottles were sourced to contain a range of solvents. Small, colored pouches are used to store cotton wool, lint-free tissue, waste bags, and eltoline tissue for emergency facing. These are labelled and referenced in the user instructions and flowcharts according to their color, which makes for quick identification. Tools for unframing and a small digital camera are also included for documentation purposes should the attack be of a less time-sensitive nature, or can be used by others under a conservator's guidance.

New mop-up pads were made of bonded carbon fabric filled with polypropylene fibers. (These pads were identified as the best performing materials in the earlier Courtauld research.) The absorption properties of the pads were retested as the manufacturing process of the carbon fabric had changed (fig. 8).

The type of PPE required conforms to European standards and caters for the extreme cases, where the most pernicious of chemicals might be used. It must be emphasized that if an acid is still reacting and causing a mist or vapor in the area, there should be no attempt to approach the area or handle the painting unless the extent of the contamination has been established, for example on walls, ceilings, or underfoot. In determining the appropriate PPE for the activities envisaged, conservators decided to follow a handling scenario that resembles that of a small-scale spill. This should be borne in mind if something of a larger scale is encountered.

The grab bags are stored at gallery level in two locations in dedicated 24/7 accessible cupboards. These spaces are closed to

Figure 7. Conservation emergency grab bag

Figure 8. Mop-up pads

the public but can be accessed quickly from the two wings of the gallery, minimizing the distance the bag has to be carried.

9. MAINTENANCE AND TRAINING

The initial cost for the Gallery grab bags was approximately £300–400 each in 2012. This is not an insignificant amount of money, especially for smaller galleries and institutions, and unfortunately it is not the end of the expense. Continued maintenance, initial staff training, and refresher training contributes a significant amount to any maintenance budget, and are essential for keeping the kit and protocol in good working order.

The Gallery grab bags are subject to yearly audits that include full inspection of the contents and replacement of any equipment, such as PPE, as regulations change. These audits are reported to the Salvage Group and in turn to the Incident Management Group as part of the NG wide Incident Management Plan. Staff who are briefed in the use of the bags (i.e., the conservators) also conduct quarterly checks to recharge the camera battery and monitor the levels of the chemicals. These checks are made to establish that the bags have not been tampered with. Finding a suitable long-term 'home' for the kits can also prove costly and challenging.

After a few aborted attempts, mishaps, and space issues, a solution acceptable to all was found. In fact, it proved the ideal solution to house other departmental response kits together in a protected but accessible way; for example, the emergency paper work required by registrars and the evacuation kits associated with the large-scale salvage and protection used by art handling.

Security for the grab bags is imperative, to protect them from damage and pilfering of "useful tools" that could render the kit useless when needed. The solution for one of two grab bags was a large red cupboard in an open corridor, back-of-house on the main gallery floor, with bold signage (fig. 9). Although not a public space, it is a general staff access area and a notorious 'dumping ground.' However, with the cupboard being highly visible, it has been possible to keep it secure and tamper free and accessible to authorized users. There have been problems with the area directly in front of the cupboard being regularly encroached upon by other general gallery equipment, such as chairs and trolleys. A well-marked "keep clear" space in front has helped mitigate this to some extent. A second cupboard was installed in a secure office off the main gallery floors and this is far easier to police in terms of obstruction.

Procuring these cupboards involved a long collaborative process between departments to agree their production, location, and signage. A callout list and protocol for using the kit was established. The conservation department has a dedicated incident number. The security duty manager alerts conservation by calling this number, which connects to six

Figure 9. Storage cupboard at the National Gallery for grab bag and other response materials

extension numbers within the department that all ring collectively until one is answered. The receiver of the call then activates the action plan.

Initial training followed by regular refresher sessions is essential, without which any response kit is likely to fall into disuse. The NG grab bags, as discussed previously, are solely for use by trained conservation staff. The first occasion the grab bags were used highlighted the need for regular staff refresher training. While the response was successful and the bag used well, members of the department not involved on this occasion expressed their concern about remembering where the grab bags were and how to use them. In response, instruction notices and bag location maps were placed in each conservation studio and office, and staff were timetabled in to undertake the quarterly checks, to use this opportunity as refresher training. The need for conservation staff to take it upon themselves to maintain their knowledge and confidence in the use of the grab bags was reiterated.

As part of all new staff induction sessions, general awareness training of the Gallery's Incident Management Plan is discussed. Those who may be involved in the recovery of paintings are also made aware of the existence and purpose of the cupboards and conservation grab bags, but that they are not to be used without conservation staff instruction. This broader-based training is organized by the Salvage Group and conducted by the art handling department. The mode of sharing information about the conservation response is being implemented, with regular sessions conducted as frequently as practicable. For the grab bags and the response protocol to be effective, as part of the wider Incident Management Plan, regular communication of the value of the bags and the collaborative responsibility of conservation staff toward the incident management plan is crucial. This is an ongoing and vital process demanding commitment and communication, albeit a repetitive and sometimes frustrating one (fig. 10).

Figure 10. Department training session with members of the National Gallery conservation department

10. CONCLUSION

In response to the 2011 spray paint attacks on two NG works, the existing response procedure and kit was revised. Previous research carried out at the Courtauld Institute of Art, London, was also reviewed. Research at the NG established that the Courtauld kit and procedure would be appropriate for the NG use. For example, mop-up materials were retested, the response procedure was streamlined, and PPE was updated. The early use of the new kit showed empirically that maintenance and training to keep the bag in good working order and cross-departmental collaboration were essential. The resources required, both initially to purchase the kit and contents, and in the longer term to maintain a functioning kit and protocol should not be underestimated. The process, however, is relatively straightforward and need not be cost-prohibitive.

The importance of preparedness policies is only too clearly illustrated as a result of previous interventions. Even though vandalism is usually impossible to predict, work undertaken at the NG demonstrates that the successful mitigation of damage is well within an institution's organizational and financial means.

NOTES

1. National Gallery Information File: Vandalism. National Gallery Archives, London, England.
2. Two paintings by Nicholas Poussin were attacked with spray paint on July 16, 2011.

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SOURCES OF MATERIALS

Comprehensive information, including a list of materials and suppliers can found online and other information about the National Gallery Incident Grab Bag can be found at http://research.ng-london.org.uk/wiki/index.php/Incident_response_grab_bag.

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A Disaster in the Making: Preserving Southeast Asian Paintings at the Walters Art Museum

ABSTRACT

Preserving Southeast Asian paintings on cloth presents challenges bridging various fields of conservation. Inherent vice and unwieldy formats stretch the boundaries of painting conservation, confronting conservators with multifaceted, and often unusual, issues. Composed of water-soluble gum-based paints, these works are extremely fragile and few survive from before the 19th century. This article discusses how the Walters Art Museum is addressing preservation of Southeast Asian paintings, improving accessibility of a large, important, and understudied collection. Conservators undertake research for improvements to storage and treatment methodologies to develop solutions for the most urgent condition issue: large areas of matte underbound flaking paint.

1. INTRODUCTION

Well known for its Western painting collection, the Walters Art Museum also houses a diverse collection of Southeast Asian paintings, which is currently one of the largest in America. The majority of these paintings were not created to be lasting artworks, but rather to be ephemeral–used, and replaced. Composed of water-soluble, lightly bound, gum-based paints, they are extremely fragile. Inherent vice and unwieldy formats stretch the boundaries of painting conservation, confronting the conservator with multifaceted, and often unusual, issues. Since entering the Walters' collection, these paintings have brought up challenges that have invited collaboration across the conservation specialties at the Walters and beyond. This article will discuss ongoing work to address the preservation and improve the accessibility of this large, important, and understudied part of the collection.

In the essay "Thai Painting in the Walters Art Museum," Thai and Cambodian Art scholar Henry Ginsburg (2009), explained that what began as a modest collection at the Walters, grew into a major resource for the study of Southeast Asian painting under former curator of Asian Art, Hiram Woodward. This growth was the result of three major gifts from private collections: that of Alexander Griswold in the 1970s, the Doris Duke Charitable Foundation in 2002, and James Bogle in 2010. The museum currently houses 125 Southeast Asian paintings, 20 wooden panels, and 105 paintings on cloth, dated between the 18th and 20th centuries mainly from Thailand, with some Cambodian and Burmese examples.

2. ORIGINS AND IMPORTANCE

In general, every work of Southeast Asian Buddhist art is an act of devotion, their donation to monasteries brought spiritual merit to the artist, the patron, and all those who viewed the artwork. Monastery complexes are extensively decorated with mural paintings, but research has shown paintings on cloth and wood typically differ in their function and imagery (Boisselier 1976, Tingley 2003). Wood panel paintings may have been substitutes for murals in open-air monasteries or decorative backdrops for small personal altars (Roveda and Yem 2010, Woodward pers. comm.). The panel paintings in the Walters' collection range in size; the larger panels (fig. 1) likely functioned as murals and the smaller (fig. 2) for personal devotion. Some of the paintings on cloth supports had similar functions, but the majority had a more temporary use (figs. 3–6).

During specific festival days, cloth paintings were often paraded, temporarily hung in or outside a monastery, and then rolled and stored away until the next festival. Several publications illustrate this usage (Tambiah 1970; Skilling 2006; Ginsburg 2009; Lefferts 2009; Roveda and Yem 2009 and 2010; Lefferts, Cate, and Tossa 2012). These cloth paintings were frequently replaced, giving merit to new artists and patrons; consequently, few examples survive from before the 19th century. The oldest known Southeast Asian cloth painting was discovered in 1906 during construction near a monastery in Chiang Mai; it is a very rare example dated to the 16th century and is now on display at the National Gallery Bangkok (Boisselier 1976, Skilling 2006).

Figure 1. *Buddha's Descent from Tavatimsa*, paint on wood, Thai, 1850–1900. 48 1/16 × 80 1/2 in. (122 × 204.5 cm). Walters Art Museum (WAM) 35.263.

Figure 2. *The Buddha with his disciples Sariputta and Moggalana*, paint on wood, Thai, 1st quarter 19th century. 16 15/16 × 11 13/16 in. (43 × 30 cm). WAM 2010.12.3.

Figure 3. *Parinirvana*, paint on cloth, Thai, 19th century. 25 × 18 7/8 in. (63.5 × 48 cm). WAM 35.285.

Figure 4. *Vessantara Jataka, Chapter 2 (Himavanta Forest)*, paint on cloth, Thai, ca. 1850–1870. 18 × 14 in. (45.7 × 35.6 cm). WAM 35.265.

The paintings served as visual aids to the recitation of Jatakas, or stories of the Buddha's previous lives. Thai paintings typically illustrate stories of the Buddha's last 10 lives—moral tales representing the 10 virtues of Buddhism, such as loving-kindness and tolerance. The majority of paintings illustrate the most celebrated story, Buddha's final life as Prince Vessantara. This story is recited by monks and illustrated in Buddhist temples across Thailand and is composed of 13 chapters totaling a thousand stanzas. The Prince gives away all that he can, including his wife and children. His limitless charity attracts the attention of the divine, and he is rewarded with the return of his family, omniscient understanding, and the restoration of his kingdom, where he is able to assume the role of ruler. After acquiring the aforementioned virtues, the Buddha-to-be was able to attain enlightenment in his last earthly life. Initially, a straightforward moralizing tale encouraging generosity, it has become rich with wit, humor, and artistic charm through centuries of retelling and illustrating (Lyons 1963a; Lefferts, Cate, and Tossa 2012; Hall pers. comm.). By the late 19th century, paintings featuring secular subjects,

Figure 5. *The Buddha with his disciples Sariputta and Moggalana*, paint on cloth, Thai, 1880–1910. 118 5/8 × 33 7/8 in. (299 × 86 cm). WAM 35.118.

Figure 6. *Narrative Scroll: Vessantara Jataka*, paint on cloth, Thai, 1st half 20th century. 194 11/16 × 36 in. (494.5 × 91.5 cm). WAM 35.291.

including historical and genre scenes, became common, although they did not replace traditional Buddhist themes (Ginsburg 2009). All of the subjects mentioned here are represented in paintings at the Walters' collection.[1]

The Walters' cloth paintings consist of several smaller series illustrating the 13 Jatakas (figs. 3 and 4), but about 30% of the collection are much larger; at least 20 are over 6 ft. long. These are in both vertical formats (fig. 5), illustrating other stories of the Buddha's past lives and in horizontal formats (fig. 6), illustrating the Vessantara Jataka scenes. The use of one format or another seems to be regional, long horizontal paintings were more common in northeast Thailand, while series of smaller paintings were more common in central Thailand (Lefferts 2009). This article focuses on the large vertical and small format paintings on cloth, from Thailand, which together make up the majority of the Walters' Southeast Asian painting collection (figs. 3–5).

The importance of preserving these paintings for future study is reinforced by the decline in production of traditional cloth paintings in Thailand in the late 19th century. It is thought this was due to changes in ritual and social practices, along with the new availability of mass-produced colored prints (Incherdchai 2002, Skilling 2006). In Thailand today, few traditional cloth paintings still exist in monasteries, most that do remain are housed in museums (Incherdchai pers. comm.).[2] In a recent and rare essay exploring the function of Thai Buddhist cloth painting, Buddhism scholar Peter Skilling (2006, 224) states, "It is surprising, and regrettable, that little has been written about the artistically and iconographically rich tradition of Southeast Asian cloth painting, which deserves to take its place next to the Thangkas of Tibetan and Himalayan cultures and the scrolls of China, Korea and Japan." Although Southeast Asian mural paintings and manuscripts have been widely studied and published, paintings on cloth have not received equal treatment from modern scholarship, possibly due to a lack of primary source material (Skilling 2006). Because scant historical documentation about cloth painting survives, and the ritual traditions do not seem to be recorded, it is imperative to develop a body of technical studies to aid in understanding the materials and techniques.

3. MATERIALS AND TECHNIQUES

English-language references to the materials and techniques of Thai cloth paintings come from limited sources that are lacking references to primary source material. Elizabeth Lyons (1963b), an American art historian who focused on Thai painting, alluded to workshop practice and stated that painters would have gone through an ordination similar to that of a monk; however, other sources identify painters as local craftsmen who made the art for merit (McGill and Chirapravati 2005; Lefferts, Cate, and Tossa 2012, Netlomwong pers. comm.). In literature about Thai mural painting, there is reference to the use of stencils, especially for drawing figures that often repeat; it is possible this practice carried over to paintings on cloth, in addition to freehand drawing and painting (Lyons 1963b; Lefferts, Cate, and Tossa 2012). Scholars note that distinct expressive lines are an important characteristic of Thai paintings (Feroci 1952), they are said to be created with brushes made of pounded tree roots and bark, while very fine details were painted with a brush made from the inner ear hair of a cow (Lyons 1963b).

The majority of the Walters' painting supports are plain weave white cloth, likely cotton, as identified through fiber analysis on several related paintings at the Five Continents Museum in Germany (Kyrianpers.comm). In addition, there are examples in the Walters' collection painted on patterned woven cloth (fig. 7), and there are similar examples in Western museum collections (McGill et al. 2009, Kyrian pers. comm.). The choice of one type of cloth support over another is an area that needs further study, but might be related to the history of gifting textiles to monasteries for merit (Skilling 2006, McGill et al. 2009).

Several technical studies have documented pigments used in Thai murals and manuscripts ranging from the 17th to the 20th century (Suigisita 1983; Prasartset 1990 and 1996; Burgio, Clark, and Gibbs 1999; Huang 2006; Eremin et al. 2008a). A manuscript study, from Harvard University Art Museum, also included seven Thai paintings on cloth from the Asian Art Museum in San Francisco (Eremin et al. 2008b). Jennifer

Figure 7. Detail of Fig. 5 showing the red, yellow, and blue patterned woven cloth support in area of paint loss at the bottom proper left corner.

Giaccai (2008) published an analysis study of pigments found in two Thai paintings on cloth from the Walters' collection dated at either end of the 19th century. The results from all studies indicate similarity in materials across all types of Thai paintings: the pigments identified on cloth paintings by Eremin et al. (2008b) and Giaccai (2008) follow the general trends observed on Thai mural paintings and manuscripts. The white ground layers studied consisted of calcium carbonate. Many pigments—vermillion, red lead, iron oxides, gamboge, orpiment, lead white, kaolin, and carbon based blacks—remained in consistent use from the 17th century; however, green and blue pigment choice changed over the 19th century. Copper citrate and malachite were replaced by emerald green, indigo by Prussian blue and later synthetic ultramarine. This is likely an indication of a transition from local to imported pigments during the 19th century in Thailand (Giaccai 2008, Eremin et al. 2008b). Lyons (1963b) described the use of local plant-based colors in traditional Thai paintings, and this is another area worthy of further study. Gold is used extensively in Southeast Asian painting; on the examples studied in the Walters' collection Giaccai (2008) found a layer of gold leaf applied over red paint, composed of a mixture of vermilion, iron oxide earths, and possibly red lead. An additional upper mordent layer, so far unanalyzed, has also been observed.

Although there is a good understanding of the pigments used in Thai paintings, little has been learned about the binding media, which are likely plant gums but have been difficult to analyze and identify (Eremin et al. 2008a). A related materials study was recently undertaken by researchers at Silpakorn University that explored difficulties with preparation and preservation of tamarind glue binders for Thai murals (Thepsuparungsikul, Pusomjit, and Saingam 2015). At least three native plant gums are referenced in the literature: (1) crushed and boiled tamarind seeds, (2) Ma-dua, and (3) Ma-kwit (Lyons 1963b, Boisselier 1977). The latter two are transliterated from Thai, and it is difficult to find exact English translations. Discussions with Thai Art scholars in Thailand and America assisted in identifying Ma-dua as likely a tropical ficus, explaining other references to "fig-rubber glue"; however, Ma-kwit has proven to be more difficult to identify (Netlomwong pers. comm., Rujivacharakul pers. comm.). Moving forward, it would be ideal to collaborate with scholars fluent in Thai—and related languages—as well as English, who could assist with finding, and translating, primary sources related to traditional materials and techniques of Thai cloth paintings.

4. CONDITION SURVEY

Receiving multiple large gifts of vulnerable, damaged objects in a short time frame resulted in a critical need for time-consuming documentation and conservation, without which the Walters' large collection of Southeast Asian paintings cannot be properly viewed by scholars or the public. The Conservation Department began to address this problem with a general condition survey, starting with the former Griswold collection, which included some of the largest paintings. Because of the huge scale and extreme fragility of the paintings, this work had to be undertaken in between other collection treatment priorities over several years.

In 2012 an Institute of Museum and Library Services (IMLS) grant assisted Walters' staff to continue surveying Southeast Asian objects from the Duke collection; including 62 of the total 125 paintings. As part of a 2015-2016 Andrew W. Mellon Conservation Fellowship project, surveying the remaining paintings on cloth began, along with research, to find

adaptations to current display, treatment, and storage approaches. Completing the general condition survey is vital to identifying the collections needs, and will provide information to create curatorial and conservation priority lists for long-range planning. Along with written documentation, the survey established a photography protocol to work toward providing high quality images on the Walters' online open-access collections database.

Ideally, each painting would be unframed for overall examination, but this has not been possible for two reasons: once unframed, it is likely the fragile paintings would require large areas for flat storage, which is presently not available. There is also concern the paintings will need immediate stabilization before rehousing, for which there is not currently space or staff resources. To conduct the condition survey, alternative solutions had to be found, with most of the paintings surveyed and photographed still framed, noting that when possible the work needs further examination once unframed. Smaller paintings could be surveyed and stabilized in the Walters' popular *Conservation Window* in an effort to inform the public about the collection and its condition issues. Temporarily closed galleries were used to store and examine larger paintings, and some of the really oversized works were surveyed and stored at an offsite facility.

4.1 Condition Issues

Prior to entering the Walters' collection, the cloth paintings had deteriorated due to inherent instability and less than ideal handling and storage. Most of the paintings suffer from actively flaking paint and ground layers, often resulting in large areas of complete paint loss (figs. 7, 8, and 9). Tightly

Figure 8. Photomicrograph detail of Fig. 3 showing area of actively flaking paint.

Figure 9. Detail of paint loss on *The Buddhas Great Departure, and Victory over Mara*, paint on cloth, Thai, ca. 1830–70. 151 31/32 × 51 31/32 in. (386 × 132 cm). WAM 35.253.

rolled or folded storage has caused wrinkles and creases in the cloth supports, leading to further paint loss in associated areas. Many show extensive linear crack patterns due to repeated rolling (fig. 10). The moisture sensitive paint layers are prone to staining and migration or loss of pigment due to water exposure (figs. 9 and 11). Some paintings have large structural losses from pest damage, and many have tears and holes near the outer edges where they were handled the most (figs. 3 and 12).

Several paintings have problematic green and blue paint, which has severely weakened the cloth support, causing darkening and shattering of the textile beneath, and in some cases there are complete localized losses of support (figs. 13a and 13b). Green paint from such a problem area on a Thai painting from the Asian Art Museum in San Francisco was analyzed at the Los Angeles County Art Museum and identified as emerald green pigment (Sasaki 2015). The deterioration was attributed to the toxic nature of emerald

Figure 10. Detail of extensive linear cracks and paint loss due to repeated rolling on *The Buddha with his disciples Sariputta and Moggalana*, paint on cloth, Thai, 3rd quarter 19th century. 73 5/8 × 34 5/8 in. (187 × 88 cm). WAM 2010.12.18.

Figure 11. Detail of staining, pigment migration, and loss due to moisture exposure on *The Buddhas Great Departure, and Victory over Mara*, WAM 35.253.

Figure 12. Detail of Fig. 15 showing structural losses. *Ten Birth Tales of the Buddha*, paint on cloth, Thai, 1790–1810. 97 41/64 × 15/32 × 36 39/64 in. (248 × 93 cm). WAM 35.300.

green; it can decompose in the presence of acids and warm alkalis, and darkens in the presence of sulfur. Blue paint from a weakened and shattered area on a Walters' Thai cloth painting was analyzed and found to contain synthetic ultramarine (Gates pers. comm.). In UV light, this blue fluoresced differently from the surrounding paint, thus the deterioration in this case may be related to interactions with a yet-to-be identified paint binder, and requires further study. It is interesting to note that in both cases these problems are related to newer pigments that came into use in the 19th century.

Many of the cloth paintings had been repaired, or received treatment, prior to entering the Walters' collection. It is likely some repairs occurred while the paintings were still in religious use. Crudely stitched tears, patches, and areas of loss backed with packing tape are unsightly and causing further stress to the paintings; however, before removal it will be necessary to take into consideration whether these repairs could be an important part of the history of the objects' use (figs. 14a and 14b). Many smaller paintings have lost their hanging rods, the rod pockets have been removed or flattened, and the paintings lined onto thick synthetic fabric, with their edges trimmed. This significantly altered their appearance making them much stiffer and flatter than originally intended. Unfortunately, it is likely irreversible and impedes future conservation processes, such as the use of suction during consolidation.

7. STABILIZATION OF THE COLLECTION

From the condition survey to date, a number of preservation issues have been identified that need to be addressed urgently.

Figure 13. Examples of problematic green paint, which has severely weakened the cloth support, causing darkening and shattering of the textile beneath.
a) Detail of *Scenes from the life of the Buddha*, paint on cloth, Thai, 1850–1870. 117 23/32 × 38 25/64 in. (299 × 97.5 cm). WAM 35.120.
b) Detail of *Scenes from the Life of the Buddha with the Buddha's Descent at Center*, Thai, 1850–1870, paint on cloth, 106 5/16 × 36 5/8 in. (270 × 93 cm). WAM 35.299.

Figure 14. Examples of crudely stitched tears and holes.
a) Detail of *Death of Buddha, and Other Events*, Thai, 19th century, paint on cloth, 73 1/16 × 37 in. (185.5 × 94 cm). WAM 2010.12.29.
b) Detail of *Buddha Descending from the Tavatimsa Heaven*, paint on cloth, Cambodian, 1954. 77 9/16 × 34 3/4 in. (197 × 88.25 cm). WAM 2010.12.30.

The top priority is stabilization and to accomplish this immediate solutions were needed for consolidating the actively flaking paint and improving long-term storage through rehousing.

7.1 Consolidation Testing

In 2013, as part of a Samuel H. Kress Fellowship project, research and testing began to determine effective

consolidation methods for the Southeast Asian painting collection. The matte nature of the unvarnished surfaces, and the large scale of many works, makes the appropriate choice and method of application complex. Consolidants used at the Walters in past treatments on related South and Southeast Asian paintings in the collection were reviewed. A large Southeast Asian cloth painting had been consolidated in 1995 with a 2% solution of sodium carboxy methyl cellulose and a 3% solution of gelatin applied by brush over a suction table. In 2001 a large (266.7 × 297.2 cm) Indian cloth painting was consolidated using aerosol application of a 3% solution of isinglass with several drops of 1% methyl cellulose.[3] This consolidation treatment took 275 hours and provides a good indication of how much time consolidation by the aerosol method could take for similarly large cloth paintings. This painting was recently reexamined 15 years after treatment, display, and rolled storage. Although the majority of the paint layer is stable, uneven gloss and sparkle were observed on the surface in raking light.

In 2011, during preparation for the small exhibition *Thai Story: The Vessantara Jataka* curated by Rebecca Hall, 13 small Southeast Asian paintings on cloth were treated. They were consolidated with a brush application of 5% isinglass and 1% funori, 1:1 in solution. This treatment effectively consolidated the smaller paintings, and the surface finish remained matte and unaffected, but there was difficulty ensuring a consistent consolidant mixture when so many steps were involved in the preparation of both the isinglass and funori. It was evident there was a need to find a more time efficient consolidation method, as well as a more consistent consolidant for the large-scale paintings.

As part of an Andrew W. Mellon Painting Conservation Fellowship project, the consolidation testing was continued in 2015 and 2016, aiming to systematically compare a variety of consolidants and delivery methods to identify effective treatment methodologies, and create a "toolkit" to draw from for future treatments. Several Southeast Asian cloth paintings came to the Walters in extremely damaged states and were categorized as study pieces. With permission from the curator, the most representative study piece was selected to test various consolidation options (fig. 15). As listed in table 1, solutions were selected for testing based on techniques that had been cited as successful for consolidating similar matte paint films, or had been specifically successful with Southeast Asian paintings. When possible, each consolidant solution was tested with application by brush, airbrush, and aerosol.[4] Each test area was then rated by the ability of the consolidant to stabilize the paint layers; the ease and speed of application; and visible change once dry, including gloss or sparkle on the surface, degree, and evenness of saturation, or the presence of tide lines.

Figure 15. *Ten Birth Tales of the Buddha*. WAM 35.300.

Table 1. Consolidants selected for empirical testing

	Consolidant	Solution*			References
		Aerosol	Airbrush	Brush	
1	Methocel A4C (methyl cellulose)	0.25%	1%	1%	Wheeler and Heady 2009, Moody 2012, Thuer 2012; Bancroft pers. comm., Levenson pers. comm., Kyrian pers. comm.
2	Klucel G (hydroxy propyl cellulose)	0.5%	1% in (2:1) water: ethanol	1% in ethanol	Quandt 1996, Lau 2012, Ng and Chua 2013, Becker 2014
3	Bermocoll EHEC (ethyl hydroxyl ethyl cellulose)	0.5%	2%	2%	Grantham and Cummings 2002, Reddington and Wheeler 2012, Weiss pers. comm.
4	Gelatin	1%	2%	2%	Maheux and McWilliams 1995, Quandt 1996; Pataki 2005, Thuer 2012
5	Gelatin : Funori	3:1 1% : 0.2%	2:1 2% : 1%	2:1 2% : 1%	Sasaki 2015
6	Gelatin : Carrageenan	3:1 1% : 0.2%	2:1 2% : 1%	2:1 2% : 1%	Fan 2012, Sasaki 2015
7	Gelatin : MC A4C	Not tested	1:1 2% : 1%	1:1 2% : 1%	Soppa 2011
8	Gelatin : Klucel G	Not tested	1:1 2% : 1%	1:1 2% : 1%	Friedman 2011
9	Isinglass	1%	Not tested	1%	Van Dyke 2009, Thuer 2012, Devesa 2015
10	Isinglass : Funori	3:1 1% : 0.2%	2:1 2% : 1%	2:1 2% : 1%	Michel 2011, Thuer 2012, Sasaki 2015, Weiss pers. comm.
11	Isinglass : Carrageenan	3:1 1% : 0.2%	2:1 2% : 1%	2:1 2% : 1%	Fan 2012, Sasaki 2015
12	Aquazol 200 (poly-2-ethyl-oxazoline)	1% in (1:1) water: isopropanol	2.5% (1:1) water: isopropanol	2.5% (1:1) water: isopropanol	Arslanoglu 2003, Ebert, Singer, and Grimaldi 2012
13	Aquazol 200 : Funori	3:1 1% : 0.2%	1:1 2.5% : 1%	1:1 2.5% : 1%	Schwarz 2012
14	Butvar 98 (polyvinyl butyral)	Not tested	3% in ethanol	5% in ethanol	Porter 2010, C. Lau 2012

*Solutions are in distilled water unless otherwise specified.

7.1.1 Preliminary observations

The testing is ongoing but some preliminary observations are available. So far stabilization of flaking paint has been most successful with gelatin, solutions containing gelatin (5–8 in table 1), and Bermocoll® EHEC ethyl hydroxyl ethyl cellulose (EHEC), followed by Methocel® A4C methyl cellulose (MC), Butvar 98, Aquazol 200:funori, and isinglass:funori. Out of the three application methods, brush application seems to give more stable results but also causes more visible surface changes. Airbrush application is the most time efficient, but the air pressure often causes displacement of loose paint. The use of suction could improve this issue, and suction has been used on past treatments to help improve penetration. It was not used for testing since some previous treatments, and the scale of many of the paintings in this collection, would preclude its use. Aerosol application caused the least disturbance to loose paint, but is extremely time consuming and even after six applications full stabilization of the paint layers was only seen with gelatin.

Every consolidant solution saturated the area treated to some degree, but it varied greatly from color to color. Butvar 98, Aquazol 200, gelatin, isinglass, and their related mixtures (4–14 in table 1) appeared to have the highest degrees of change, although application by aerosol or airbrush at lower concentrations does seem to minimize the saturating effect. Since some degree of saturation may be inevitable, one question we need to address is what is an acceptable change when undertaking overall consolidation of these matte underbound paint surfaces? The surface changes of most concern are the development of uneven gloss and sparkle after consolidation, similar to that seen on the large Indian cloth painting mentioned in section 7.1. Gelatin:MC, EHEC, and all the solutions mixed with funori or carrageenan (5, 6, 10, 11, and 13 in table 1) showed the greatest degree of sparkle and gloss after drying. The single consolidant solutions (1, 2, 4, 9, 12 and 14 in table 1) showed less surface changes but gelatin, isinglass, and Butvar 98 showed some gloss in raking light. Additionally, airbrush application of Butvar 98 left white residues on the surface.

On related consolidation treatments at the Walters, prewetting areas to be consolidated with alcohol to break surface tension had helped wick-in the consolidant. During brush application testing, it was found that leading with ethanol caused significant tide lines, especially for the mixed solutions containing gelatin or isinglass (5–11 in table 1). Fewer tide-line issues were observed with airbrush and aerosol applications. The cellulose ethers (1–3 in table 1) and Aquazol 200 showed the least evidence of tide lines.

As described in section 7.1, in the past, there had been success consolidating similar cloth paintings at the Walters with solutions of mixed consolidants, but so far many of the single-consolidant solutions are giving better results than the mixtures of two. Having started testing with a large number of consolidants, the next step would be to narrow the list on the basis of initial observations and consider if there are any other consolidants that should be added to the testing. Once the list is refined, it would be beneficial to test a wider range of solution concentrations and try using a variety of distilled water:alcohol ratios as the diluents (Becker 2014).

7.2 Storage and Rehousing

The majority of the Southeast Asian paintings on cloth came to the Walters tightly rolled, sometimes folded, or in a variety of collectors' frames inadequately supporting the paintings and causing structural stress. Many are sandwiched between glass or mounted to acidic mats and backing boards with duct tape, packing tape or staples (figs. 16 and 17). Now stored in environmentally stable conditions, the collection is in urgent

Figure 16. *Revolt of a Prince*, Cambodian, 1890, paint on cloth, 70 7/8 × 27 9/16 in. (180 × 70 cm). WAM 2010.12.15

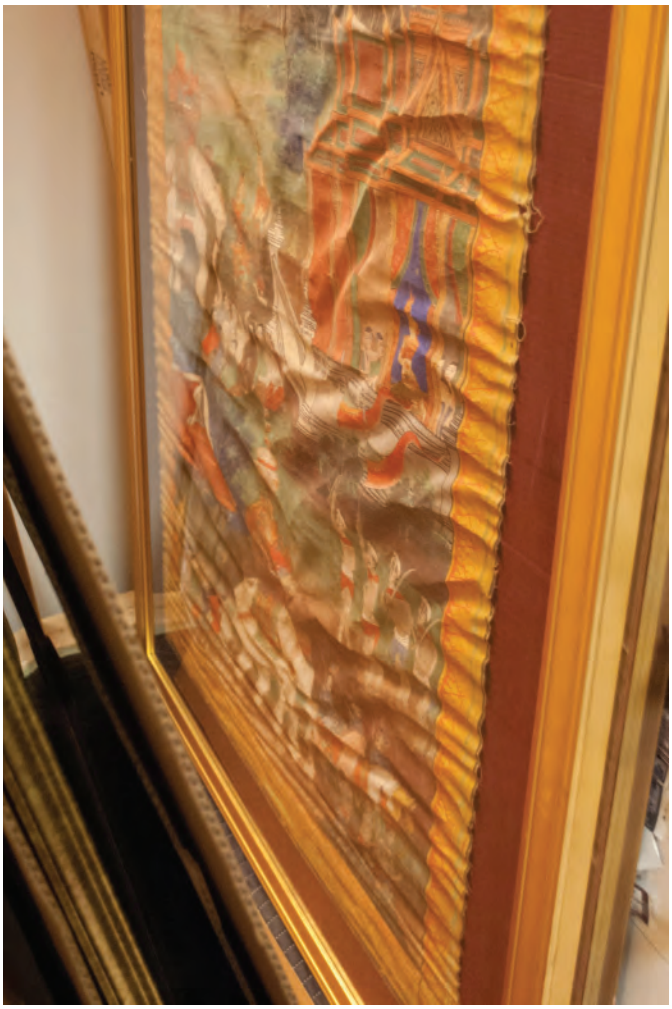

Figure 17. Detail of Fig. 16 showing the cockled painting in the collector's frame sandwiched between glass and an acidic matboard.

need of rehousing. Ideally, this collection of fragile paintings should be stored flat; however, many are 3 feet. or longer and current space constraints challenge long-term storage and the process of unframing and rehousing.

Storage improvements have been made gradually, for example, as part of the IMLS survey large tightly rolled paintings were rerolled after photography around larger diameter acid-free tubes, interleaved with acid-free tissue. In preparation for the small exhibition mentioned in section 7.1, 20 of the smaller Thai cloth paintings were removed from detrimental acidic housing, treated, and mounted in new frames with acid-free mounts. There is still much work to be done; therefore, an important part of the Mellon Fellowship project was to explore both ideal and adaptive housing and storage systems that would be well suited for the Walters' Southeast Asian painting collection. Focus was placed on finding inexpensive, modular, movable solutions with a small spatial footprint (Walker and Woods 2005, Facini 2005, Bellman 2009). Storage spaces of museums housing similar collections were visited to see what they were using (Bancroft pers. comm., Harper pers. comm., Incherdchai pers. comm., Komatsu pers. comm., Lau pers. comm., Netlomwong pers. comm.). The institutions visited had simple ideas for adapting painting racks and using compact shelving units for storage of rolled paintings. Deep front opening drawer units and compact rolled storage were also possible solutions. Different rolling techniques were observed, for example, interleaving with thick batting and tissue, creating padding to decrease stress on the paint, and for a very long painting spreading it around two tubes instead of one to keep the roll diameter small enough to fit a specific drawer height (Komatsu pers. comm., Lau pers. comm.). Knowledge gained through visits and research aided in writing a rehousing and long-term storage plan for when more space and resources are available.

Discussions with conservators of East Asian scrolls introduced us to futomaki storage rollers which could be built and modified using a variety of materials (Hare 2006, Smith 2011, Freer Gallery of Art and Arthur M. Sackler Gallery 2015, Weiss pers. comm.). Futomaki are commonly used with East Asian scrolls to increase roll diameter of the rods and alleviate some stress to the artwork. After exploring available resources, modified rollers were created for currently unframed paintings in the collection, specifically those that were still tightly rolled around scroll rods (fig. 18). The materials used were archival unbuffered storage tubes and thick Tyvek (fig. 19). A strip slightly wider than the scroll rod was cut out along the length of the tube, and thick Tyvek with double-sided tape created a recessed pocket to hold the scroll rod, allowing the paintings to be rolled around a wider diameter and lessening the stress on the paint layers. Polyethylene foam cradles support the ends of the rolled paintings while they are being stored on shelves (fig. 20). Ideally as time, space, and resources permit, more of the large cloth paintings will be removed from collector's frames and rehoused this way. Flat storage boxes will be created for smaller unframed paintings, and Walters' registrars are working to create space to store the newly housed paintings, modifying existing shelving units to accommodate deep drawers for rolled storage.

8. DISPLAY

Southeast Asian paintings are rarely on permanent display in Western collections. The Walters has had a few small temporary exhibitions for which some paintings received conservation treatment, but the majority of them are not in stable enough condition for safe or sustainable display. This part of the collection needs devoted attention and has been

Figure 18. Two examples of paintings on cloth that came to the Walters tightly rolled on scroll rods.

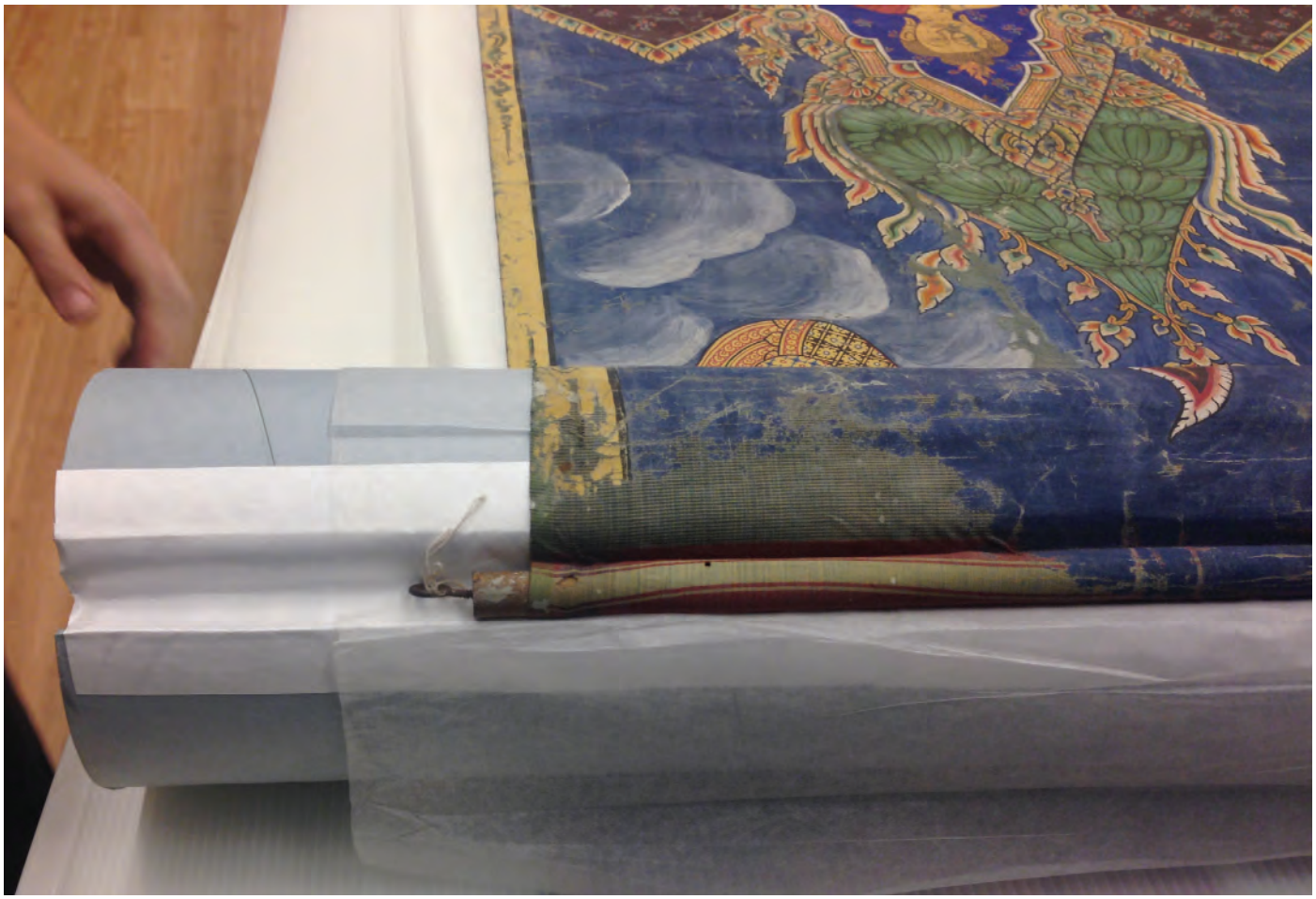

Figure 19. Detail of modified roller created to store unframed paintings in the collection.

Figure 20. Detail of painting rolled on modified roller resting on foam cradles.

designated the highest priority for stabilization and treatment by the painting conservation department. This in turn has led to renewed curatorial interest and development of a plan for a gallery displaying rotations of Southeast Asian art, due to open in late 2017. A major challenge is how to best display these paintings and maintain a balance between their traditional formats, how they have been modified over time, and what keeps them best supported and preserved. Many of the paintings on cloth originally hung suspended by wooden rods at top and bottom (Skilling 2006, Roveda and Yem 2010). Only a few in the Walters' collection retain these hanging devices although many show evidence of having had them (figs. 5–7, and 18–20).

In Thailand, the largest collections of cloth paintings are in Bangkok at the National Gallery, the Jim Thompson House Museum, Suan Pakkad Palace, and the Siam Society (Skilling 2006). During research visits to these collections in 2015, most of the large paintings on cloth were seen exhibited in scroll format hanging from rods. However, at the Jim Thompson House some large paintings had been stitched onto new supporting textiles, and at Suan Pakkad Palace the majority had been framed behind glass. Most of the smaller paintings on display were framed. Overall, the cloth paintings on display showed visible damage but appeared stable. Minimal cleaning or loss reintegration was apparent in contrast to many of the mural paintings seen in monasteries in Bangkok and Chiang Mai, which evidenced highly visible areas of inpainting. There are several publications containing images of paintings on display in some of these collections (Subhadradis Diskul and Voraphitak 1982; Warren and Beurdeley 1999; Jotisalikorn, Phūmathon, and Di Crocco 2002).

9. CONCLUSIONS AND FUTURE WORK

Concurrent with research and the condition survey, an extremely helpful network of colleagues dealing with Southeast Asian painting collections was established. Visits were made to museums with similar paintings in the United States, the United Kingdom, Thailand, and Singapore. The Walters organized a research forum in March 2016 with support from the IMLS: "Thai Banner Forum: Discussing Difficult Treatment and Storage Issues for Long Southeast Asian Painted Textiles." Conservators from a variety of disciplines were brought together—painted surfaces, paintings, textiles, books, and paper—to brainstorm ideas for treating one of a series of long horizontal cloth paintings from the Duke collection (fig. 6). Much of the generated discussion was relevant to the Walters' Southeast Asian painting collection as a whole and the forum further expanded our networking list. Interesting discussion ensued at the forum as to whether large paintings on flexible supports should be rolled face out or face in, and what materials should be used as an interleaf, if any. It became apparent there are currently no standard procedures as to how Southeast Asian cloth paintings should be displayed, treated, or stored. The creation of an international network of professionals dealing with similar issues should be a great resource for better care of these paintings worldwide, and will help to establish such procedures.

The more insights and information we gain with regard to material composition and traditional use of these paintings the better we are able to preserve them. In the future, the Walters hopes to connect with those in Thailand studying binders and use the Southeast Asian painting collection to undertake in-depth materials research and analysis. The recent project focus has been completing the Southeast Asian cloth paintings survey. The panel paintings remain to be surveyed, and the Walters recently started a joint project with the Winterthur University of Delaware Art Conservation Program to examine and treat one of the largest of them (fig. 1). Southeast Asian paintings present unique and complicated treatment and storage problems; their care requires international collaboration across multiple conservation specialties. One of the main reasons for presenting and publishing this work is to inform many people about the challenges in hopes of initiating further discussions and solutions.

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NOTES

1. Images of the Walters' collection paintings can be found in Tingley 2003, Ginsburg 2009, Lefferts 2009, and Bogle 2011.
2. While planning the 2002 installation of traditional Thai paintings at the National Gallery Bangkok the curator, Jarunee Incherdchai, visited many monasteries that were documented as having paintings in their collections. In almost every case, the paintings were not found at the site, leading her to believe that they no long existed.

3. The aerosol equipment used was the AGS 2000 HS Aerosol-Generating System.
4. The airbrush equipment used was the *Iwata Airbrush HP-BC*. The aerosol equipment used was a Michalski et. al. (1994) style ultrasonic mister composed of an ultrasonic humidifier, an aquarium pump and a low-density polyethylene bottle.

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The Painting Materials and Techniques of J. E. H. MacDonald: Oil Sketches from 1909 to 1922

EXTENDED ABSTRACT

J. E. H. MacDonald (1873–1932) was a distinguished Canadian artist of the early 20th century. He was one of the founding members of the association of painters known as The Group of Seven and is recognized particularly for his paintings of the Algoma landscape. This presentation provides results from a research project on MacDonald's painting materials and techniques. The information obtained from the project will lead to a better understanding of MacDonald's working methods and will provide valuable reference data for paintings of uncertain attribution or authenticity. The results will also inform storage and display decisions and future conservation treatments of his paintings.

Algoma Hills, 1920 by J.E.H. MacDonald (1873–1932), oil on paperboard, 21.4 × 26.4 cm, Gift of Mr. R.A. Laidlaw, McMichael Canadian Art Collection, 1966.15.6

MacDonald's career can be divided into five major periods: Early (1908–1917), Algoma (1918–1921), Nova Scotia (1922), British Columbia and Georgian Bay (1924–1931) and Barbados (1932). A representative group of 32 works (21 oil sketches and 11 paintings) spanning his oeuvre was chosen for the project. All the works were examined under magnification and using ultraviolet illumination. Microscopic paint samples were analyzed using a combination of Fourier transform infrared (FTIR) spectroscopy, x-ray diffraction (XRD), scanning electron microscopy/energy dispersive spectrometry (SEM/EDS), polarized light microscopy (PLM) and Raman spectroscopy.

The presentation will focus on 13 of MacDonald's oil sketches that range in date from 1909 to 1922. These sketches are particularly important in MacDonald's oeuvre; they document significant changes in his method, from his earliest works, where he was developing his style and painting technique, to his more characteristic sketches produced during trips to Algoma and Nova Scotia. Results presented will include a discussion of the support, the use of preparatory layers and sealing layers, the choice of pigments and pigment mixtures, and aspects of his painting technique.

MacDonald used various types of paperboard for the majority of his sketches. The dimensions of his supports changed over the 1909–1922 period; while his early sketches are of variable dimension, he began to favor a standard board size as his technique evolved. Although he used a ground layer on a number of his early sketches, he later abandoned this practice and simply sealed his boards with shellac prior to painting. The paintings from his early period show a multilayered, wet-on-wet application and a muted palette. In the later works, he employed brighter colors, confidently applied with little layering, and left the support or ground layer visible at brushstroke edges. Some of MacDonald's commonly used pigments include viridian, ultramarine, alizarin lake, vermilion, cadmium yellow, chrome yellow, chrome orange, and iron oxide pigments. The white pigment in almost all the sketches from the 1909–1922 period is a mixture of zinc white and lead sulfate. This characteristic white paint was also widely used by other members of the Group of Seven and its source has recently been established as the Cambridge Colours paint brand.[1] A magnesium carbonate filler (hydromagnesite) was also found in some of MacDonald's paints. Although common in Winsor & Newton oil paints, this is not a filler used in the Cambridge Colours, indicating that MacDonald employed more than one brand of paint during the period under investigation.[2]

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The History, Technical Study, and Treatment of Francis Bacon's *Painting* (1946)

ABSTRACT

Francis Bacon's seminal work, Painting *(1946), has suffered from inherent material vulnerabilities since its creation in London in early 1946. The painting's condition issues, related to the fragile, faded, and flaking pastel background have been addressed at least three times since the painting entered the Museum of Modern Art's collection in 1948. Dissatisfied with the painting's condition and appearance, Bacon proposed scraping down and repainting the background on two occasions, though the proposals were never realized. In 1971, the painting was treated at the Museum of Modern Art, prior to its travel to Paris for Bacon's retrospective at the Grand Palais. Bacon viewed the treatment at that time as a magnificent restoration, but 15 years later, the extensive areas of retouching had faded substantially. In 2015, the pastel areas were cleaned and consolidated, and the faded retouching reduced and redone. This article describes the 2015 treatment methodology, imaging and analytical findings, and explores the impact of the painting's history and Bacon's own artistic philosophies as they relate to that methodology.*

1. HISTORY

1.1 1946–1948: The Role of Chance, Conflicting Oral Histories, and Material Innovation

In early 1946, Francis Bacon created *Painting* (fig. 1), in his studio at 7 Cromwell Place, South Kensington. Soon after its creation, the painting was purchased by Erika Brausen of the Redfern Gallery, and later of the Hanover Gallery from which the Museum of Modern Art (MoMA) acquired the painting, providing Bacon with the funds to move to Monaco, where he remained until the early 1950s. With ambitions to place the work in a prominent museum collection, Brausen sent Alfred Barr an image of the painting in the summer of 1948. On August 5, Barr replied to Brausen, stating that he was "afraid we could not take a chance on buying a painting so horrifying as Francis Bacon's picture sight unseen to our trustees" (Barr 1948). *Painting* travelled to New York for a viewing during which Barr made a successful pitch for acquisition to the Board of Trustees. With the acquisition of *Painting* in November of 1948, MoMA became the first museum to own a painting by Francis Bacon.

Though Bacon would later describe *Painting* as his breakthrough work, in multiple published interviews with David Sylvester, Bacon touted the idea that the striking composition arose by mere chance. He recalled in the interviews that he initially set out to paint a bird of prey landing on a field, but that a few stray marks led him down an unintended path, culminating in the image we see today (Sylvester 1980).

Figure 1. Francis Bacon, *Painting* (1946), before treatment, 2015, digital image courtesy of conservation department, MoMA, N.Y. © 2016 Estate of Francis Bacon/Artists Rights Society (ARS), New York/DACS, London

Images of contemporaneous works suggest a somewhat different genesis than the one Bacon portrayed in his interviews with Sylvester. Photos of *Study for Man with Microphones*, 1946 (fig. 2), which Bacon later repainted and subsequently destroyed, depict very similar compositional themes to *Painting*, which was most likely painted after the abandoned work. In *Study for Man with Microphones* a black-suited figure stands within a railed structure, before an array of microphones, with the upper portion of his face concealed by a black umbrella. Bacon scholar Martin Harrison proposes that the similarity of these two images suggests the creation of *Painting* was less the result of chance than Bacon implied in the published interviews (Harrison 2009).

Though x-ray radiography completed in 2015 does not reveal the presence of a clear bird-like figure, it does show that significant reworking has occurred in the lower half of the composition (fig. 3). Two drumstick-like shapes are revealed at the left of the central figure and may be indication of the lower limbs of the flayed carcass having been laid in prior to the painting of the central figure. The upper part of the flayed carcass appears to have been laid in as one solid area of lead white paint, save for the areas on the upper limbs where the ground layer is left exposed. The carcass was then divided with a wide black vertical, giving it a stronger cross-like appearance, and detailed with ribs and musculature in reds and purples.

Figure 2. Francis Bacon, *Study for Man with Microphones* (1946) © 2016 Estate of Francis Bacon/Artists Rights Society (ARS), New York/DACS, London

Figure 3. *Painting* (1946), composite x-ray radiograph, 2015

Additional linear brushwork is revealed below the figure. Rounded linear, furrowlike shapes are visible throughout the bottom of the composition and may be related to the plowed field that Bacon's original bird of prey was said to be alighting upon. The curved linear marks are also reminiscent the palm fronds at the foreground of *Study for Man with Microphones*.

Whether or not *Painting's* composition truly resulted from a series of accidents, the materials that Bacon used to make the painting certainly deviated from time-tested tradition and this experimental use of materials has resulted in an extremely fragile structure that likely began showing its instabilities almost as soon as the paint was laid down on the canvas. Bacon purchased his linen canvas pre-primed with a white oil-based

ground layer. Though later in his career he would routinely paint on the unprimed side of the commercially prepared linen canvas, *Painting* was made on the primed side. The foreground elements were painted in what appears to be artists' oil paint, with thick impasto brushwork throughout. The pink background and purple window shades, by contrast, were made with crushed pastel mixed into a slurry, possibly with water, and applied by brush. Bacon explained his choice to paint with pastel as purely a result of his inability to find Phoenician Red, the vivid magenta color he desired, in paint form (Mahon 1984). The resulting paint layer is—and has always been—extremely fragile, prone to flaking due to poor adhesion to the oil ground, and the colorant susceptible to fading from light exposure.

It is evident from Bacon's letters from 1946 that the pastel areas were suffering from instability almost immediately following its creation and sale to Brausen. In August of the same year, prior to an exhibition of the painting in Paris, Bacon wrote to his friend, the artist Graham Sutherland, thanking him for "spraying" the painting, likely an allusion to Sutherland having applied fixative to the pastel areas (Bacon 1946). The effectiveness of the fixative is unknown, though its presence may account for the pastel's relative cohesiveness as a layer, as well as its tendency to flake rather than to powder.[1]

1.2 1959–1971: Bacon Pleads to Repaint

After MoMA's acquisition of the work, *Painting* continued to suffer from severe material instability and on two separate occasions, Bacon proposed scraping down the flaking and fading background and repainting it with more robust materials.

In 1959, Bacon first proposed to repaint the background in oil paints, prior to an exhibition of the work at the São Paulo Biennial. Though the repainting was never carried out, correspondence between Dorothy Miller, who was then the curator of Museum Collections, and Lilian Somerville, director of the Fine Arts Department of the British Council and British Commissioner at the São Paulo Biennial, suggests that the museum did consider allowing Bacon to do so (Miller 1959).

Bacon's second proposal to repaint the background came in 1971 as part of an entreaty to the museum to allow the fragile, but seminal painting to travel to Bacon's 1971–72 retrospective at the Grand Palais in Paris (Bacon 1971). In his second appeal, Bacon proposed repainting the background in acrylic emulsion paints, as was standard in his practice at the time (Russell 2009). He suggested that not only would the acrylic emulsions be more stable than the pastel, but also noted that repainting would allow him to re-establish the original, more saturated color relationships. Bacon's expression of a desire to regain the original saturated colors is the first written documentation that the original pastel colors had visibly faded. MoMA denied this second request to repaint the background, but proposed that the museum's paintings conservator, Jean Volkmer, carry out the repainting in his place.

1.3 1971: A Conservative Compromise

Volkmer's initial proposal reflected Bacon's wishes and indicated her willingness to do as Bacon would have himself—scraping down the flaking background and carrying out a wholesale repainting of the pastel areas to restore them to their original saturated colors. To aid her efforts, the museum requested that Bacon send swatches of the pastel colors as he remembered them prior to fading. In response, Bacon sent two color swatches, which have since been retained in the painting's conservation file (figs. 4, 5). The swatch for the purple window shades is painted with what appears to be a fluid household type paint on a scrap of printed paper torn from a book or magazine. Bacon's swatch for the pink background, while very close in color to the oil saturated areas of the pastel background, was not painted, but was rather cut from an offset printed sheet of semigloss paper. After seeing Bacon's swatches and imagining the dramatic and likely historically inaccurate change that the painting would undergo if repainted to match them, Volkmer proposed a more conservative treatment that would entail preserving the original paint in its faded state and inpainting existing losses. Though Bacon continued to encourage Volkmer to scrape down the flaking areas and repaint them in acrylic emulsions, he sanctioned Volkmer's more conservative proposal. Volkmer's modified proposal called for the preservation of the original materials, despite their faded condition, by overall consolidation and retouching of areas of loss with pastel.

Volkmer's treatment report directly reflects the conservative approach of her modified proposal to Bacon. In her report, she states that:

> The pastel areas were tested extensively for an adhesive that would not stain this medium. Gelatin size was best suited, and the lifting edges surrounding losses were treated locally to prevent further flaking. Whole areas were then sprayed with the gelatin size to bond the powdery layers of pastel which are no longer held together. For the extensive losses, pastel sticks were reduced to powder and applied by brush followed with a sprayed on solution of gelatin. This process was continued in layers until the depth of the losses were fully compensated. Where possible, some areas were dry-cleaned.

Following the treatment at MoMA, the painting travelled to Paris for Bacon's retrospective at the Grand Palais. Bacon saw the treated painting while it was on view in Paris and expressed his approval of the treatment results in a letter to

Figure 4. Color swatch for purple window shades, painted semigloss paper, provided by Francis Bacon, 1971

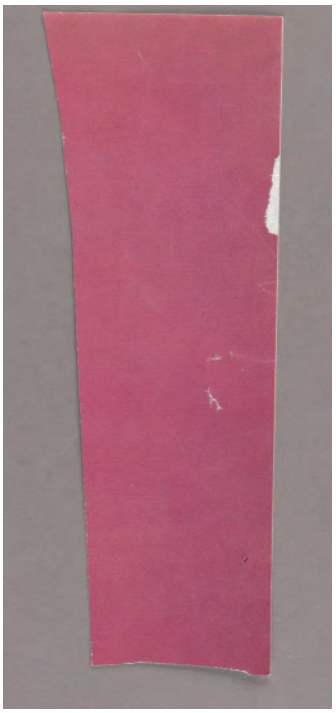

Figure 5. Color swatch for pink background, offset printed semigloss paper, provided by Francis Bacon, 1971

MoMA, in which he described Volkmer's work as a "magnificent restoration" (Bacon 1972). Bacon is pictured in Figure 6 with his sister, Ianthe Knott, in front of *Painting* at the Grand Palais. This important image, captured by Andre Morain, functions as the only existing after-treatment documentation of the painting's appearance just after the 1971 treatment was completed. In the photograph, it is apparent that there are no visible areas of loss and the pastel fields appear evenly toned.

1.4 1984: Bacon Visits MoMA Conservation

In May 1984, Bacon and the Tate Gallery's assistant keeper, Richard Francis, came to visit the conservation studio at MoMA and looked at *Painting* together with the museum's conservators. On seeing the painting, Bacon expressed a new approval of the faded original pastel areas stating that the lighter colors gave the painting more depth than the colors did prior to fading. He called for the painting to be preserved as he saw it in 1984, which set a new benchmark for future preservation, including for the most recent treatment.

1.5 1984 – Present: Persistent Condition Problems and the Charge to Re-Treat

Since Bacon's 1984 visit and prior to the current treatment, at least one attempt has been made to consolidate the persistently flaking pastel. The consolidation effort, which was made in

Figure 6. Francis Bacon in front of *Painting* (1946) with his sister, Ianthe Knott, at the Grand Palais, 1971 © Andre Morain, courtesy Francis Bacon MB Foundation/MB Art Collection

2002, was done locally with Funori. Condition notes from the 2002 treatment suggest that tidelines and rings of saturation, attributed to the 1971 gelatin consolidation, were visible throughout the pastel areas.

An updated condition assessment of *Painting* was made in 2015, when the painting returned to the conservation studio for x-ray radiography. At this time, new losses were noted and tented flaking was visible in broad areas of the pastel passages. Although on first examination, it was not known that the patchy appearance of the background was a result of retouching in 1971, the areas of paler pastel and contrasting brushwork were noted. When the 2015 condition was compared with before-treatment images from 1971, it became clear that the pale blue patches were indeed overpaint extending far beyond the boundaries of the losses as they existed in 1971. The dramatic fading of the overpaint resulted in an accentuation of the nonoriginal brushwork. Figures 7 and 8 show the same area before treatment in 1971 and 2015.

In response to these findings, enthusiastic curatorial support was given for a new treatment that would address the material fragility of the original as well as the disfiguring alterations to the 1971 conservation materials.

2. TECHNICAL STUDY

Prior to undertaking any treatment steps, the painting was thoroughly documented and analysis was completed to gain a better understanding of both the original and nonoriginal materials. Analysis was also completed on materials deemed useful for the proposed treatment, to determine their long-term suitability for use in the conservation of *Painting*.

2.1 Photo Documentation

All studio imaging was done with a Sinar CTM (Color-To-Match) multispectral dual-pass filter system, with a multishot-capable eVolution 86H digital back with the standard infrared filter removed.[2] The CTM system produces highly accurate color reproduction, which will be invaluable when assessing any potential color shift that occurs in the future.

Figure 7. *Painting* (1946), before-treatment detail, 1971

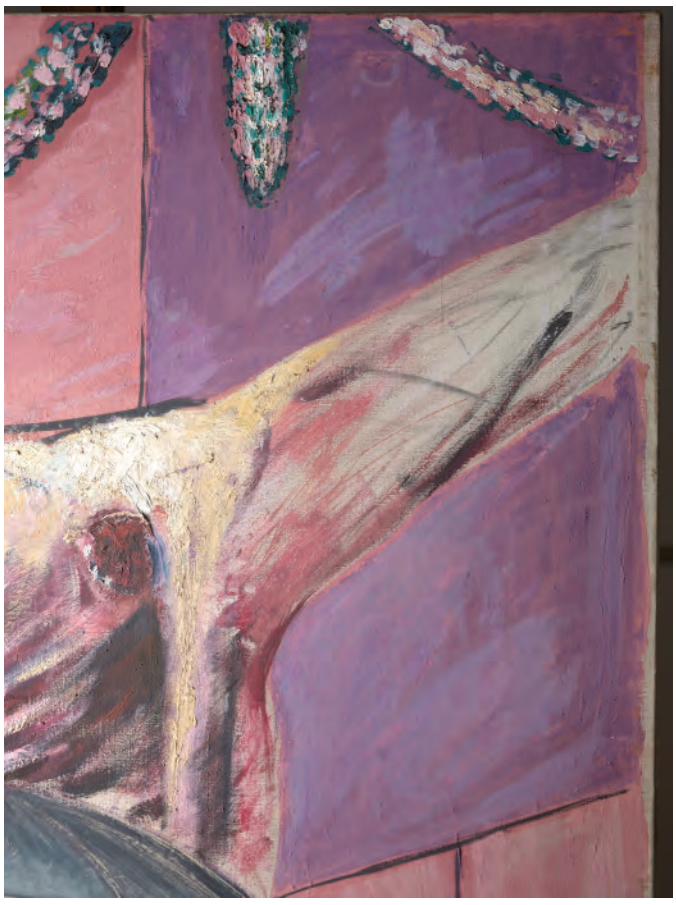

Figure 8. *Painting* (1946), before-treatment detail, 2015

UV-induced visible fluorescence imaging was done according to the UV Innovations workflow, with the CTM dual-pass filter set removed from the Sinar and with a Kodak 2E gelatin UV filter and PECA 918 visible-pass filter affixed on the lens in their place (UV Innovations 2014). UV-induced visible fluorescence examination and imaging was effective in delineating the extent of the broad 1971 retouching and areas of contrasting fluorescence in discreet areas of retouching that suggest the possibility of additional retouching campaigns (fig. 9). The comparatively bright fluorescence of the ground and lowest layers of original pastel also aided in revealing the extent of the loss to the original beneath the retouching (fig. 10).

Reflected and transmitted infrared imaging were both useful in revealing additional information about the extent of loss to the original material and the extent of retouching. The reflected infrared image clearly indicates the boundaries of the 1971 campaign, particularly in the purple window shades where the IR absorption of the original and the nonoriginal materials are quite distinct (fig. 11). Transmitted infrared imaging, on the other hand, was more useful in revealing the extent of loss below the extensive retouching (fig. 12).

Figure 9. *Painting* (1946), before treatment, 2015, overall UV-induced visible fluorescence

Figure 10. *Painting* (1946), before treatment, 2015, UV induced visible fluorescence detail showing extent of losses

2.2 Polarized Light Microscopy of Original Pastel

In 1985, the samples of the original pastel background were analyzed by polarized light microscopy (PLM), revealing that the background is composed of two colored pigments, plus colorless fillers. The pink pigment is a red lake pigment, of a red dye cast onto a calcium carbonate base, and the purple pigment is cobalt violet. The samples showed that the pink background is predominantly the red lake with trace cobalt violet and that the purple window shades are a mix of cobalt violet and red lake. The colorless fillers were estimated by PLM as chalk and baryte (Ordonez 1985).

Figure 11. *Painting* (1946), before treatment, 2015, reflected infrared

Figure 12. *Painting* (1946), before treatment, 2015, transmitted infrared

The identification of the red pigment as a dye-based lake situates it in a class of the most light-sensitive pigments, explaining the rapid early fading of the pastel passages. Analysis has not yet been completed to determine the exact class of dye used to make the lake. As the cobalt violet in the window shades is comparatively stable, when the dye-based red began to fade in the window shade areas, the overall color mix shifted toward blue. The original color of the window shades was likely closer to a raspberry color, while the pink areas were likely a more saturated magenta. The digital restoration pictured in Figure 13 is suggestive of how the painting may have appeared before the background colors faded so dramatically. Areas of the original pastel that had either been masked from light exposure by the frame or revealed by loss of upper layers were used to estimate the colors prior to fading. Photoshop was used to increase the saturation in the faded pastel passages to match these comparatively less faded areas.

Figure 13. *Painting* (1946), digital restoration of faded background

In 1985, no sampling and analysis were done on the areas of retouching, which may suggest that the color difference between the original and nonoriginal materials was not so apparent at the time.

2.3 FTIR Analysis of Original and NonOriginal Materials

During mechanical removal of the 1971 retouching, samples were retained for analysis. One sample (sample 1) was taken from the 1971 retouching in the upper left purple window shade. A second sample (sample 2) was taken from retouching at the left edge of the pink pastel on the left side of the painting. A third sample (sample 3) of original pastel was identified and taken from the right edge pink section for reference.

Only sample 1 had a readily identifiable binder. The binder was identified as gum, which is consistent with the traditional composition of chalk pastels (Gettens and Stout 1966). The FTIR results for sample 1 also showed the presence of protein, which could have been from the gelatin or Funori used in past treatments. Sample 2 had no indication of binder, which may indicate that the sample had a lower concentration of binder than sample 1. A hot water extraction was also performed on sample 2, which further confirmed the existence of protein in the sample, but failed to provide any information on a possible binder. It was not possible, therefore, to confirm whether samples 1 and 2 had the same original binder.

Using FTIR, no binder was detected in sample 3. Although an oil extraction was performed, the results were inconclusive. The peaks of spectra produced from the oil extraction were not strong enough to give a definitive answer. A hot-water extraction was also performed on sample 3 to investigate whether the sample contained any proteinaceous material; no protein was identified.

2.4 Microfadeometry of Original and Proposed Retouching Pastels

The fading of the 1971 retouching pastel emphasized the risks of using pastels for the most recent inpainting efforts, but small tests showed that pastels were the best retouching media for producing an acceptably matte surface. To ensure the stability of the new retouching pastels, microfadeometry was carried out on the original paint and on a set of Sennelier pastels, selected on the basis of their color for retouching. The microfader is based on the design by Whitmore, except for the 100-µm fiberoptic cable, which consisted of a bifurcated 6 (to detector) around 1 (from source) design with a 1–2 mm working distance (Whitmore, Pan, and Bailie 1999). The original paint showed a lightfastness comparable to a Blue Wool 3 standard, suggesting that the original paint still has the potential for moderate fading. Any pastels that were significantly less lightfast than the original were ruled out for use in treatment.

2.5 Cyclomethicone Evaporation Study

Small cleaning tests on the original pastel revealed that an application of cyclomethicone D5 allowed for safe aqueous cleaning of the pastel through tissue, reducing the aged gelatin, without the formation of new tidelines. To ensure that the cyclomethicone evaporated from the painted structure completely following treatment and to define a safe window after cleaning for the application of local consolidant, tests were carried out to determine the rate and completeness of evaporation.

XRF (x-ray fluorescence spectroscopy) was carried with a Bruker Tracer III-SD (Rh tube, operated at 15keV, 18microA, 60s acquisition time, and He purge) and was used to detect the presence of unevaporated residues of cyclomethicone on the basis of the Si signal intensity on paint mock-ups. The mock-up samples set included a raw canvas sample (#10 cotton duck) and paint outs of Sennelier pink and dark pink pastel (#946 and #935) crushed with a mortar and pestle and mixed with water to make a slurry of gouache-like consistency that were then painted out with a brush onto an oil primed (commercial priming) linen canvas. The pastel samples were intended to mimic the structure of *Painting*'s fragile pastel passages.

Each type of cyclomethicone was brushed onto left half of each sample over Japanese tissue with a nylon bristle brush and the right side was to be used as a reference. Spectra were acquired on recto and verso over five days on the six mock-ups. A small Si peak is always present, as it is intrinsic to the instrument. Cyclomethicone was considered to be present if the Si peak was larger than the peak observed for the reference side of the sample that had not been treated with cyclomethicone. In the XRF spectra example (fig. 14), the spectra in red correspond to the canvas cleaned with cyclomethicone D5 after two days and is higher than the peak for the reference side of the sample evidencing that the D5 had not evaporated completely. Results indicated that Si from cyclomethicone D4 was undected by XRF after one day and from cyclomethicone D5 after three days. As cyclomethicone D5 was ultimately used for the treatment, it was determined four days following cleaning was a safe window for beginning local consolidation efforts.

The results confirmed an ATR-FTIR (attenuated total reflectance Fourier transform spectroscopy) preliminary study to determine the rate of evaporation by brushing the diamond crystal with D4 or D5 and following the disappearing

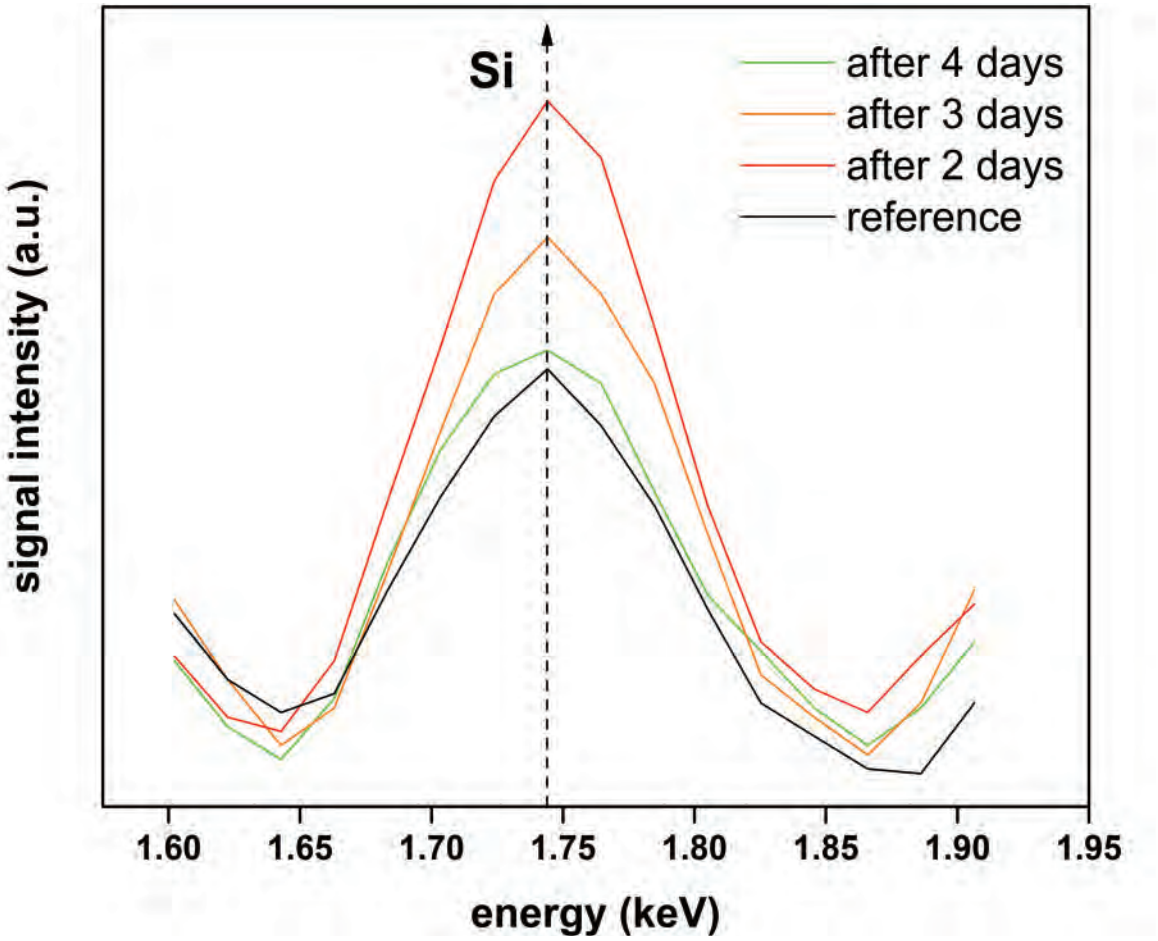

Figure 14. Decreasing Si characteristic peak in the XRF spectra acquired for the canvas sample treated with D5 over the course of four days

characteristic absorption bands over the period of five days. (Analysis was carried out with the Thermo Nicolet iS50 FT-IR.)

3. TREATMENT

With curatorial support to proceed with treatment, goals were set and a strategy laid out according to results of small-scale cleaning, consolidation, and retouching tests.

For the cleaning process, Cyclomethicone D5, which is the slower evaporating of the two commonly used silicone solvents, was applied in approximately palm-sized areas with a soft nylon bristle brush to minimize the formation of tide lines during aqueous cleaning. With the pastel saturated with the silicone solvent, the areas were cleaned with soft cotton swabs lightly dampened with deionized water rolled gently over Japanese tissue. The cleaning resulted in a brighter surface and also functioned to relax the lifting areas and produced a more stable surface after drying, possibly a result of residual 1971 gelatin being reactivated with moisture. This effect minimized the need for additional local consolidation, but allowed for it wherever it was still needed, without forming dark tidelines.

The minimal local consolidation was done with Tri-Funori, a purified seaweed-based consolidant, which dries matte, making it an ideal choice for the underbound pastel. It was found that Tri-Funori was easier to work and produced cleaner results than unpurified Funori and was significantly more cost effective than the super purified alternative JunFunori.

Following cleaning and consolidation, the faded areas of 1971 retouching were reduced mechanically, using small shavings of vinyl erasers. After removing the upper layers of faded retouching, it was apparent that much of the original had been removed prior to retouching in 1971, just as Bacon had suggested. The loss of original found below the retouching was

Figure 15. *Painting* (1946), during treatment procedural image, showing original pastel after partial removal of faded 1971 retouching, 2015

much more extensive than that pictured in the 1971 before treatment images. The exposed areas also appeared more red than the surrounding original pastel, suggesting that the 1971 retouching had a protective effect, shielding the underlying original paint from further fading from light exposure (fig. 15).

With the original surface exposed, goals for reintegration were set according to Bacon's 1984 wishes to preserve the original in its faded state. The full losses would be inpainted, and the areas that had been covered and protected by the 1971 retouching would be toned to reintegrate with the surrounding faded original. Digital restorations of the 1971 before treatment images were used to determine the appearance of Bacon's original strokes, where much of the original material had been removed. The Sennelier pastels that were deemed to be acceptably lightfast by microfadeometry were crushed to a fine powder and made into a thin slurry with the application of deionized water. A narrow sable brush was used to apply the pastel slurry, reestablishing the appearance of Bacon's original strokes.

Figures 16 and 17 show *Painting* as it appeared before and after treatment in 2015.

3.1 Reflections on Treatment

By cleaning and stabilizing the original pastel, reducing the faded 1971 retouching, and reintegrating areas of loss with more stable materials to match the faded original, the latest treatment was a compromise between restoring the painting to its original appearance and respecting Bacon's wishes that the painting be preserved in its faded state. The result is a painting that is as stable as its original materials will allow, which is well cared for but doesn't hide the effects of time on its fragile structure.

In 1971, David Sylvester asked Francis Bacon to describe the relationship between a great painting's effect and its material substance, and Bacon responded:

> I think it has to do with endurance. I think that you could have a marvelous image made of something which will disappear in a few hours, but I think the potency of the image is created partly by the possibility of its enduring (Sylvester 1980).

Though *Painting* 1946 will always be an inherently fragile work, which has been marked by the passage of time, its potency has only increased since its creation and it is hoped

Figure 16. Francis Bacon, *Painting* (1946), before treatment, 2015, normal illumination

Figure 17. Francis Bacon, *Painting* (1946), after treatment, 2016, normal illumination

that this latest conservation effort will allow this sensational image to endure well into the future.

NOTES

1. Analysis of the underbound pastel did not show the presence of any material commonly used as a fixative at the time, though a very low concentration of fixative may not have produced a sufficient signal during FTIR analysis.
2. Sensor: Dalsa FTF 6080C–RGB Mosaikfilter, Full Frame Technology Size of Sensor: 8000 × 6000 Pixel, 48.8 Mio Pixel/48.0 × 36.0 mm

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Whitmore, Paul M., Xun Pan, and Catherine Bailie. 1999. Predicting the fading of objects: identification of fugitive colorants through direct nondestructive lightfastness measurements. *Journal of the American Institute for Conservation* 38 (3): 395–409.

SOURCES OF MATERIALS

100-μm fiberoptic cable
Multimode Fiber Optics, Inc.
9 Main St.
Chester, NJ 07930
http://www.multimodefo.com.

Sennelier Soft Pastels (Numbers 366, 095, 784, 364, 363, 307, 274)
Dick Blick Art Materials
P.O. Box 1267
Galesburg, IL 61402
http://www.dickblick.com/

Tri-Funori (Adhesive derived from Gloiopeltis furcata and Gloiopeltis tenax species of red seaweed)
26 Barrett Street
Port Hope, Ontario
Canada L1A 1M7
https://tri-funori.com/.

Cyclomethicone D5 (Cyclotetrasiloxane)
Kremer Pigmente GmbH & Co. KG
Hauptstr. 41–47
DE 88317 Aichstetten
http://shop.kremerpigments.com/en/
http://www.kremerpigmente.com/media/ files_public/87081_MSDS.pdf.

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JESSICA FORD, HAIDA LIANG, and CHI SHING CHEUNG

The Mellow Pad by Stuart Davis: A Treatment and Technical Study

ABSTRACT

Stuart Davis took six years to complete The Mellow Pad *(1945–51; fig. 1), an innovative and complex painting that is a highlight of the Brooklyn Museum's American Art collection. The painting has significant, inherent condition issues: recurring interlayer cleavage and localized paint discoloration. Bank of America awarded an Art Conservation Project grant to thoroughly study and treat the painting in preparation for exhibition travel. With the grant goals as the framework, this article will use historical documentation and noninvasive technical study to better understand these condition issues and the artist's working practice.*

Figure 1. Stuart Davis, *The Mellow Pad*, 1945–51, oil on canvas, 26 1/4 × 42 1/8 in. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

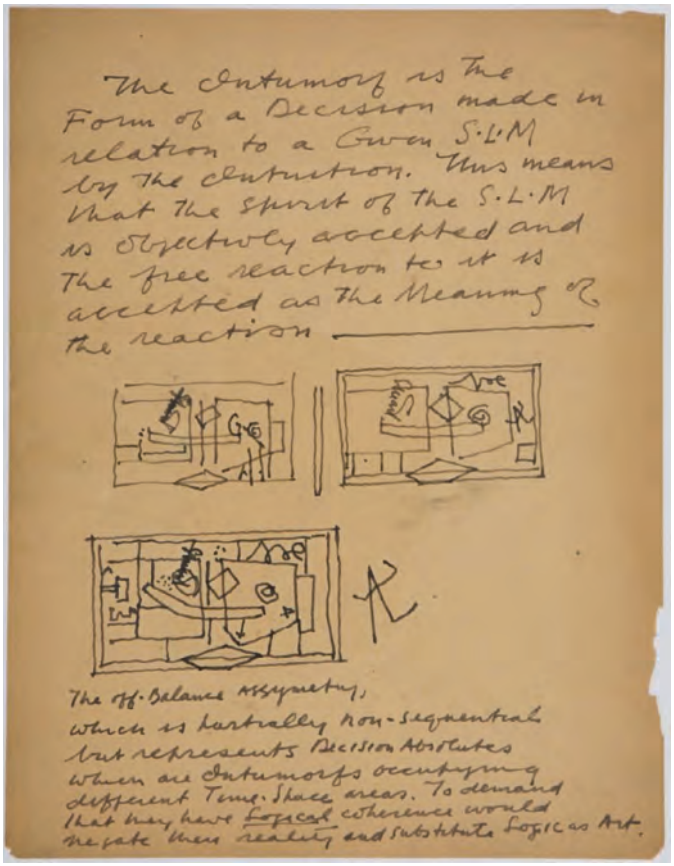
1. INTRODUCTION

1.1 The Mellow Pad

Stuart Davis (1892–1964), the son of two artists, began forming his own career at Robert Henri's progressive art school in Manhattan as a teenager (Phillips 1962). At age 20, Davis had five Ashcan-style artworks in the 1913 Armory Show, after which he began experimenting in the styles of the European avant-garde (Phillips 1962). These influences, along with his immersion in New York's urban environment and his love of jazz music, shaped Davis's distinct style. His paintings bridge Synthetic Cubism and Abstract Expressionism, and even serve as a precursor to Pop Art with his consistent use of advertising and slang phrases (Kelder 1991). All throughout his bold, five-decade-long career, the fast pace and spontaneity of American life and jazz music were brought into vibrant focus.

Davis's approach to art was methodical—inspired by everyday life, developed through detailed line drawings, and completed with carefully determined color intervals to achieve an all-over balance in visual action (Seckler 1953, Phillips 1962). During the 1940s, his notes and sketches reveal extensive theorizing about "color-space logic," or the notion that each color has an architectural size and shape, and pairings are especially crucial (Lane 1991, Wilkin 2007). These ideas were painstakingly worked out over a period of six years for *The Mellow Pad* (figs. 2a, 2b, 2c, 2d), the most complex of Davis's compositions, yet the finished picture reads as the embodiment of lively improvisation.

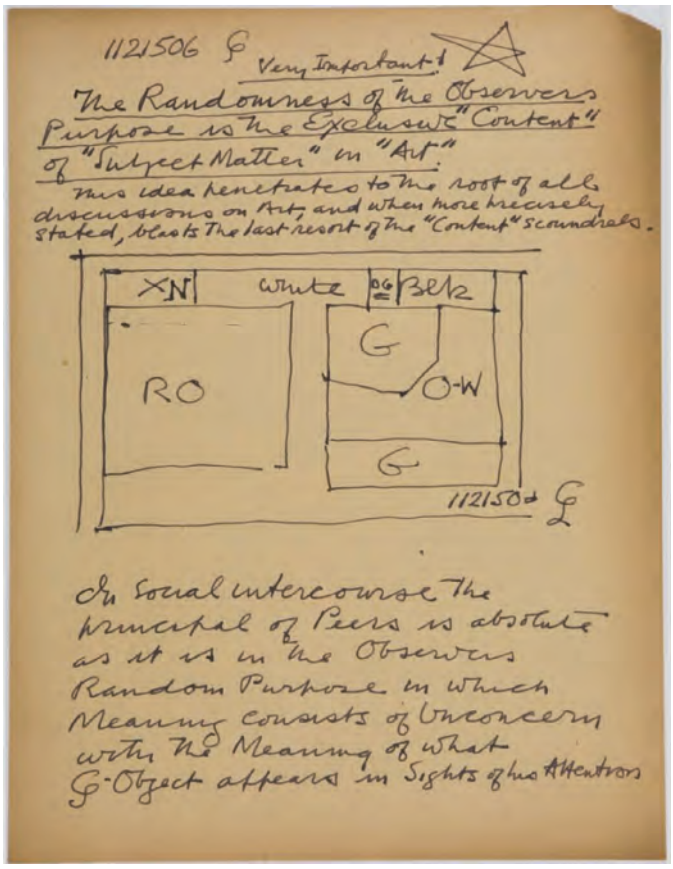
The Mellow Pad, an oil painting executed on artist-primed canvas, was originally attached to a five-member wooden stretcher, on the reverse of which Davis inscribed the painting's title, his name, and the date range of creation in black paint. The inscribed top member of the stretcher has been preserved, but the painting is now wax-resin lined and mounted on a later expansion bolt stretcher. *The Mellow Pad* has varying paint thickness due to the lengthy reworking process. Some painted



2a

2b

Figure 2. Stuart Davis, (a) *Study for The Mellow Pad*, 1947, 1967.79.415 (b) *Study for The Mellow Pad*, 1947, 1967.79.422 (c) *Color Diagram for The Mellow Pad*, 1950, 1967.79.574 (d) *Study for The Mellow Pad*, 1947, 1967.79.607. Courtesy of Harvard Art Museums/Fogg Museum, gift of Mrs. Stuart Davis.



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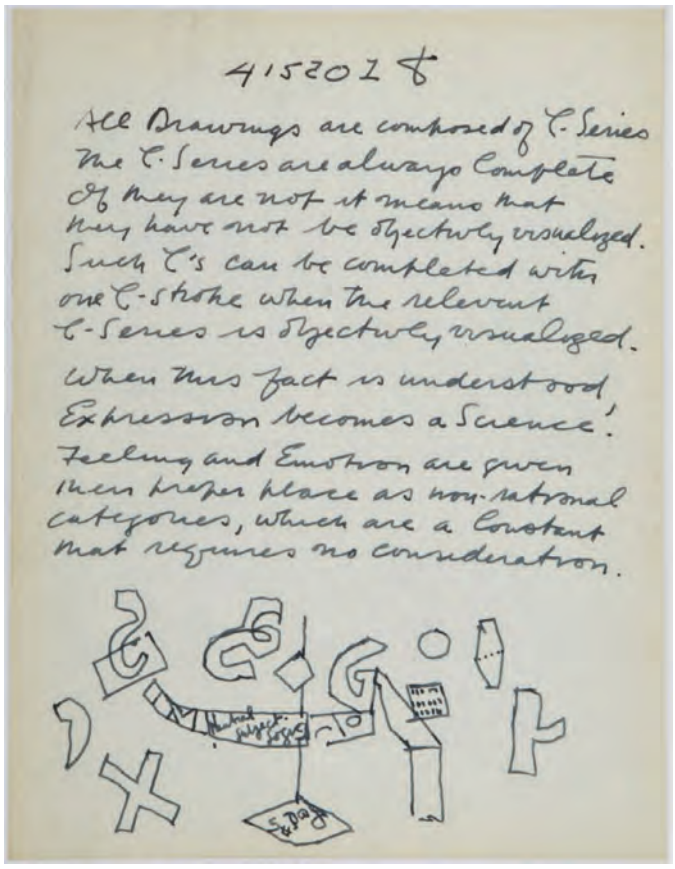


2d

shapes still retain the weave texture of the underlying canvas, while others are nearly ¼ in. thick. The painting retains its original, painted white frame with a protruding square profile, a design that Davis favored throughout his career.

The painting, upon completion, was purchased from the artist by Davis's friends and American art collectors Edith and Milton Lowenthal. In 1992, the Brooklyn Museum acquired *The Mellow Pad* by bequest (Boyajian and Rutkoski, 2007).

1.2 Bank of America Grant

In the spring of 2015, *The Mellow Pad* and two other Davis paintings in the Brooklyn Museum collection were requested for the retrospective exhibit, *In Full Swing: The Art of Stuart Davis*, opening at the Whitney Museum of American Art and traveling to three additional venues. The loan review of the artwork prompted critical interest in two significant condition issues. The recurring problem of interlayer cleavage was once again active, and the various faded appearance and selective discoloration of specific colors over time was discovered.

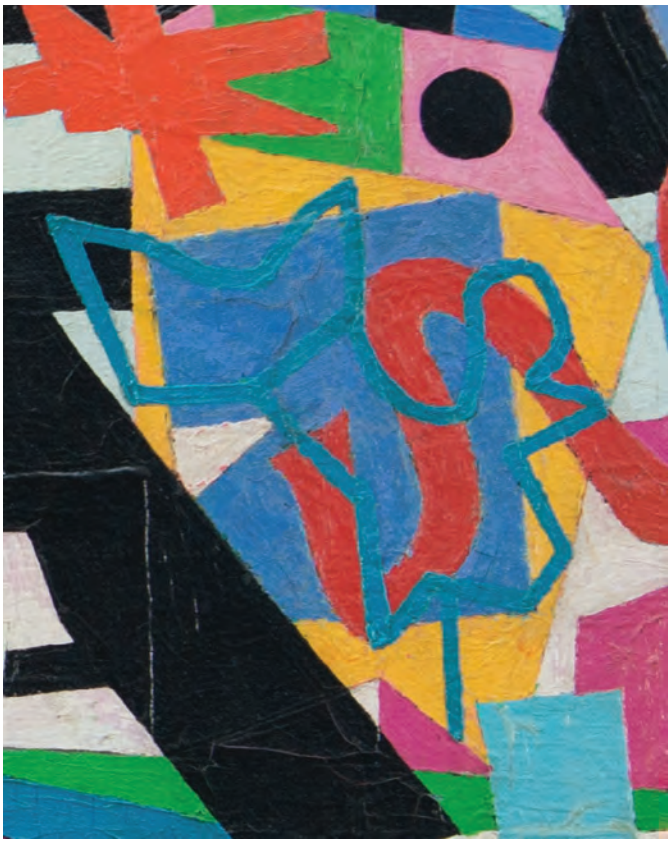
Former Andrew W. Mellon curator of American Art Terry Carbone and author Jessica Ford, with input from the Brooklyn Museum's development department and Carol Lee Shen chief conservator Lisa Bruno, applied for a Bank of America grant to sponsor a closer look at the painting. Given the importance of the picture and the upcoming exhibition, as well as the need for published technical literature on Davis,[1] the grant was awarded. The project goals were to directly benefit the painting through treatment and to help preserve Davis's legacy by contributing to the literature and increasing awareness of the artist's influential presence in 20th century art history.

2. TREATMENT

2.1 Treatment History

Lifting paint layers in Stuart Davis's work are not uncommon. *The Mellow Pad* has a documented history of lifting and flaking dating back to the 1970s. Letters from 1977 refer to conservator Jean Volkmer performing a wax-resin lining treatment in response to severe paint cleavage (Lane 1977, Volkmer 1977, figs. 3a, 3b). Unfortunately, the lining treatment did not permanently fix the flaking problem, probably due in part to incomplete penetration of the wax-resin adhesive through the many layers of thick paint. Ten years later, the painting required consolidation again, and it has now received a total of nine recorded stabilization treatments.

3a



3b

Figure 3. Stuart Davis, *The Mellow Pad*. (a) Detailed image of paint cleavage and loss before treatment in raking light in 1977 and (b) current state in normal light for reference. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

2.2 Treatment Methodology

The minor upside to having a painting with a long history of lifting paint is that it serves as its own case study for the success of the treatment materials used. Thorough documentation made it clear that some areas previously consolidated were once again lifting.[2] However, areas treated with BEVA-371 had not reopened, so dilute BEVA-371 (10% w/v in 80:20 petroleum benzine:xylene), brush-applied and followed with low heat and mild pressure, was used for the current treatment (figs. 4a, 4b). The painting was then monitored in the Brooklyn Museum galleries for three months and encapsulated in a microclimate made with Tru Vue Optium Museum Acrylic and Marvelseal 360 Barrier Film prior to travel.

3. TECHNICAL STUDY

3.1 Methodology

The noninvasive technical study utilized the already in-house techniques at the Brooklyn Museum: microscopic examination, portable x-ray fluorescence spectroscopy (p-XRF), and x-ray radiography. The grant provided funds for the acquisition of multiband imaging (MBI), reflectance transformation imaging (RTI), and fiber optic reflectance spectroscopy (FORS). Instrumental details are contained in the Appendix. Additionally, the grant sponsored authors Liang and Cheung to bring their in-house-built optical coherence tomography (OCT) instrument to the Brooklyn Museum to perform analysis.

This range of techniques was selected to characterize colorants and to document the evolution of the painting over its six years in Davis's studio, especially in areas of flaking and discoloration. FORS, XRF, and spectral imaging have been used synergistically in multiple recent studies to identify colorants without removing any samples (Delaney et al. 2014, Kogou et al. 2015). For this study, FORS and p-XRF allowed for colorant characterization, with support from the overall image maps produced with MBI. X-ray radiography has been used for decades to ascertain details of hidden paint layers, and OCT would ideally further elucidate the painting's layer structure. OCT, RTI, and microscopic examination would all provide further understanding of surface characteristics and evidence of layering based on topographical clues.

4a

4b

Figure 4. Stuart Davis, *The Mellow Pad*. Detail of lifting paint (a) before treatment and (b) after treatment. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

3.1.2 Optical coherence tomography (OCT)

OCT, like many analytical techniques used in the study of art, was adopted from the biomedical field (Liang 2014). Over the last 12 years, OCT has found numerous applications in the field of art conservation, history, and archaeology (Liang et al. 2008, Targowski and Iwanicka 2012). In recent years, authors Liang and Cheung have been developing purpose-built OCT devices for the analysis of cultural heritage (Cheung, Spring, and Liang 2015, Cheung et al. 2015). In their work, OCT has been used with great success to view subsurface information non-invasively (Cheung, Spring, and Liang 2015). While OCT has been successfully applied to the study of old master paintings (Spring et al. 2008, Cheung, Spring, and Liang 2015), this is the first time it has been applied to a modern art painting.

The instrument used in this study utilizes a purpose-built ultra-high resolution OCT at a depth resolution of ~1.2 μm (fig. 5). The broad band near infrared (NIR) laser at a central

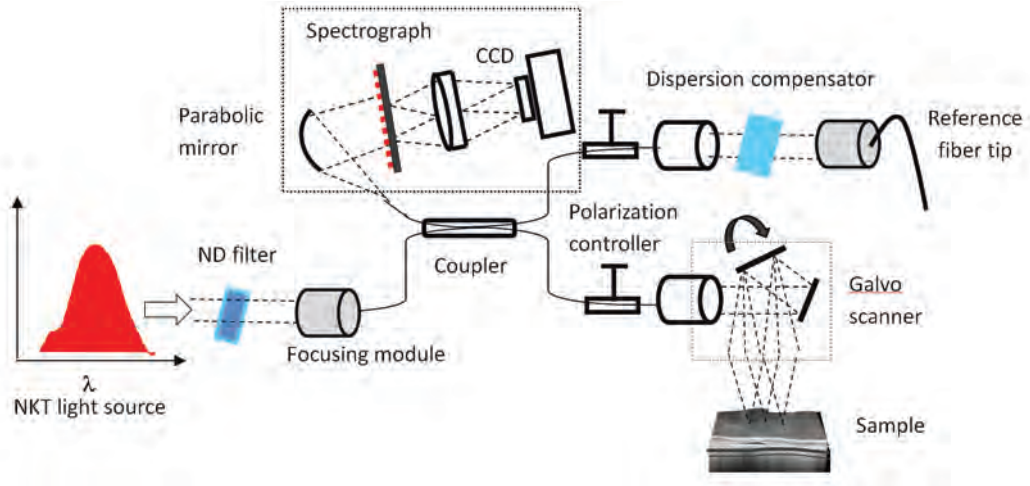


Figure 5. Diagram of the 810 nm ultra-high resolution OCT device.

wavelength of 810 nm is essential to the OCT, and the broader the spectral bandwidth of the laser, the higher the spatial resolution in depth. The laser beam is separated into two paths with half the beam reflected from a reference mirror and the other half directed to the painting through an automated scanning head with two small mirrors scanning in perpendicular directions across the painting. The light reflected from the reference mirror is then recombined with the light scattered back from the painting and recorded by the internal spectrometer. The spectrometer signal is then converted into a depth profile through a Fourier transform, which shows how much light is returned from each depth. The reference path is used to judge how far the light traveled back from a certain scattering center in the painting.

Each scan is 5 mm in length and ~1.8 mm deep. The physical depth of penetration is determined by how the scanned material responds to the light; that is, how much it absorbs and scatters light. The OCT was set to take 500 scans in succession to cover an approximate 5 mm square surface area (fig. 6a). The result is a virtual cross section cube that can be viewed from multiple angles, using any individual cross section or any selected depth of the surface (figs. 6b, 6c). A series of thin slices in depth parallel to the painting surface can also be visually averaged, to create highly detailed IR images of layers in depth. Additional details about the instrument are given in Cheung, Spring, and Liang (2015).

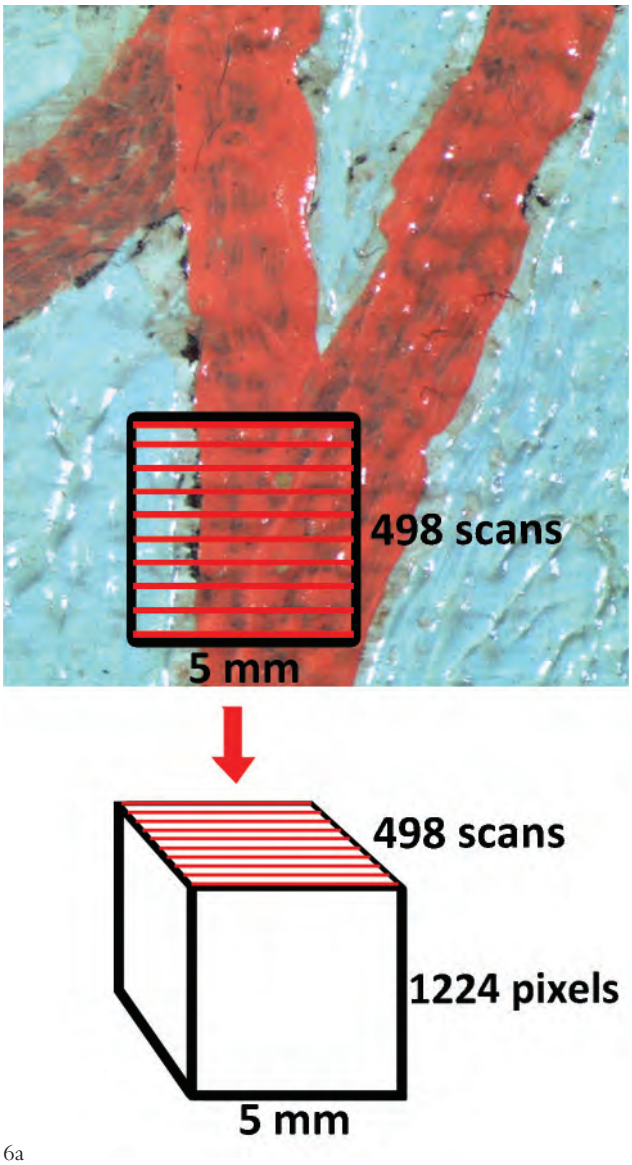
There are two main keys to interpretation. OCT cross section images do not show actual thickness, but rather optical thickness, and each interface in the cross section represents a change in refractive index. To work out actual depth, one can divide the optical thickness of a layer by the refractive index, which is ~1.5 for oil paint and varnish. Since actual thickness was not pertinent to this study, images were not corrected in this way. Colorants also affect interpretation. Opaque pigments, such as titanium dioxide, scatter the light and obscure lower layers. Colorants that absorb IR, like charcoal, stop the light completely and also prevent viewing lower layers.

The scattering effect of opaque modern pigments (titanium white, cadmium colors, etc.) turned out to be a significant limitation for examination of *The Mellow Pad*. However, variation in scattering and absorption did help distinguish some materials. In general, the technique proved most useful for the examination of the stratigraphy visible within boundaries between colors; crack structure, and materials seeping forward through cracks or applied over them; and the condition of the surface coating. A long wavelength OCT at a central wavelength of 1960nm, also developed by Cheung and Liang, can potentially overcome the opacity of these pigments (Cheung, Spring, and Liang 2015). Author Liang continues to examine the data gained from this study for potential additional uses, such as combining OCT, p-XRF, and FORS data for colorant identification.

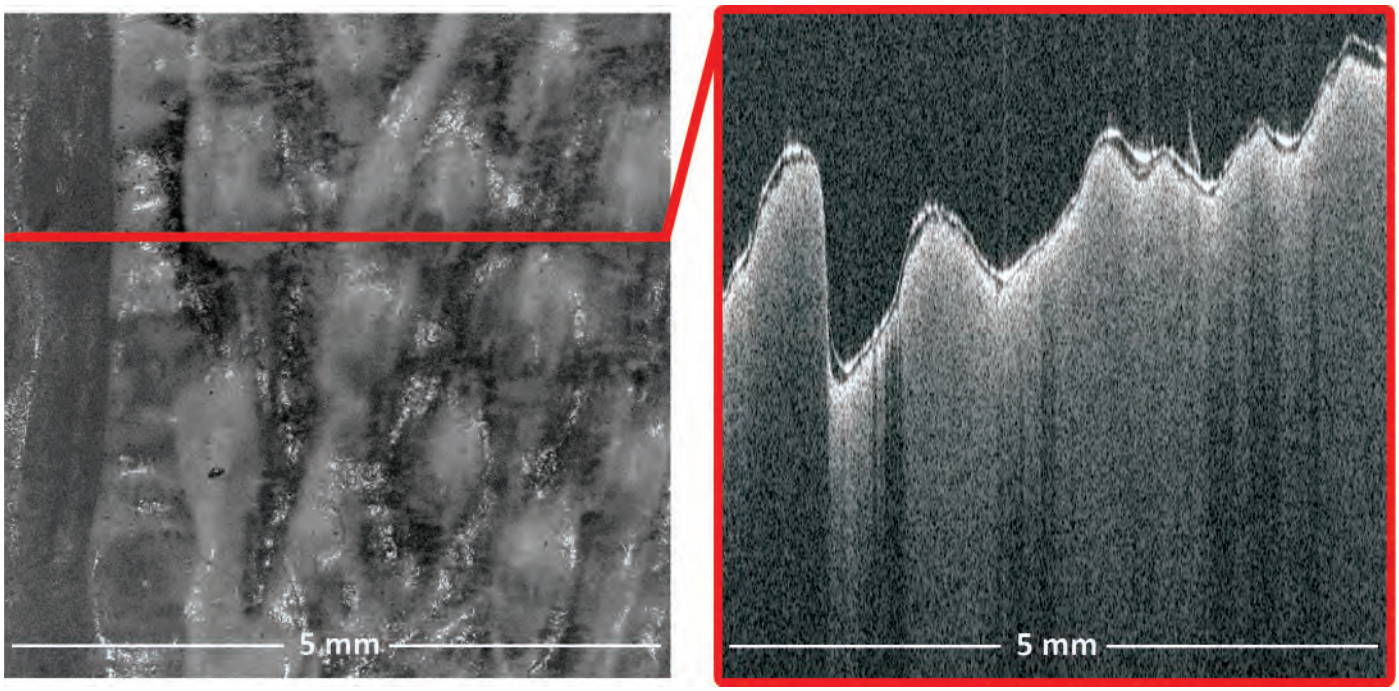
3.2 Results and Discussion: Flaking Paint

3.2.1 Chalk underdrawing

From the 1940s onward, Davis based all of his paintings on previous compositions. Like with jazz music, he believed that a single good configuration could be the source of endless riffs and interpretations; most important was to critique and transform the previous variation (Wilkin 2007). *Rapt at Rappaport*, a painting created the year after Davis finished *The Mellow Pad*, demonstrates this transformative practice. It is also a rare case when some of the artist's exact materials were recorded, thanks



6a



6b 6c

Figure 6. Illustration of acquisition of a cross section cube using a detailed image of the "D" in the signature (a). The surface image (b) obtained from the image cube of the cross sections (c). In the cross section, the bright line at the top is the interface between air and the overall synthetic coating, which appears dark due to its transparency. Both the blue and orange paint exhibit multiple scattering, which prevents viewing the stratigraphy underneath the top layer of paint. The particulate, NIR-absorbant material of the underdrawing appears as dark vertical lines at the surface of the boundary between blue and orange paint layers, and also just below the surface of the semi-transparent orange. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

to a timely *Artnews* feature on the artist by Dorothy Seckler (1953). This painting was based on an old sketch from Gloucester, and Davis worked through his critique and transformation of the sketch on the primed canvas (Seckler 1953).

In the *Artnews* feature, Davis is described to be using white chalk to edit his charcoal underdrawing for *Rapt at Rappaport* (Seckler 1953). The black design was first set with "turpentine" (Seckler 1953, 74), which must have contained a resinous component. The white chalk was added afterwards, leaving an underbound layer onto which paint would be applied. Davis's methodical approach to his work suggests that many aspects of his technique would have carried over from one painting to the next.

The Mellow Pad was based on Davis's 1931 painting *House and Street* (Lane 1978, 63). Davis's 96 sketches on paper from throughout *The Mellow Pad*'s creation indicate that he played with the design in the same way as he did with *Rapt at Rappaport*, although in this case the compositional riffing continued for much longer (Stuart Davis Papers). Photomicrographs also show evidence of charcoal beneath and in between layers (fig. 7) as well as incised lines (fig. 8), showing the rigorous compositional planning taking place on the canvas.

It should be noted that *Rapt at Rappaport* does not have a record of instability (Lake 2002), in spite of having a known chalk layer. It has also been glue-paste lined as opposed to wax-resin lined (Shar 1971), and has significantly fewer layers of paint. A comprehensive condition survey of Davis's paintings would provide a better sense as to whether there is a pattern between flaking paint, lining practices, and layering techniques.

3.2.2 Zinc-containing pigments

Zinc-containing pigments and their proneness to saponification and chalking over time are a known source of interlayer cleavage in a number of 20th century artists' work (Kühn 1986; Rogala et al. 2010). P-XRF was used to confirm the presence of zinc across the entire composition (table 1). Because of the penetrating nature of x-rays, the p-XRF readings contained elemental information from multiple layers of paint. FORS, a technique that relies on spectral reflectance to yield

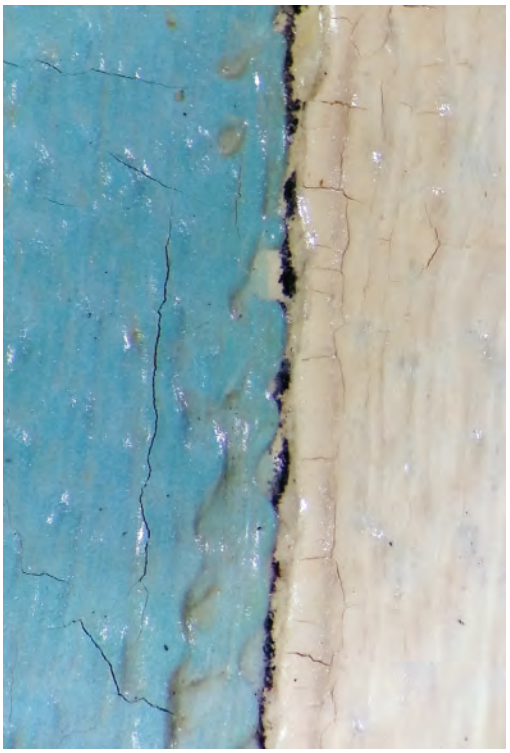


Figure 7. Photomicrograph showing charcoal outlining, 16x. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

Figure 8. Photomicrograph showing incised vertical line in paint, 16x. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

Table 1. Summary of p-XRF results for flaking areas

Top layer color *(observed underlayer(s))*[a]	p-XRF Major, *Minor*, *(Trace)*	Top layer colorants likely *(Underlayer colorants likely)*
Deep yellow	Cd, *Ti, Pb, Zn, Se, Sr, (Ba)*	Cadmium yellow, cadmium red, organic colorants *(titanium white, zinc white, lead white)*
Bold red *(orange)*	Cd, Se, *Ti, Fe, Zn, (Mn), (Pb), (Sr)*	Cadmium red, iron earth colorants *(titanium white, zinc white, lead white, additional)*
Peach *(black)*	Ti, Zn, Pb, *Al, Se, Cd, Fe, Mn, Sr, (Ba)*	Titanium white and/or zinc white, cadmium red, red lake *(titanium white and/or zinc white, lead white, mixed black*[b]*, additional)*
Light blue *(orange, green, teal)*	Ti, Cd, Se, *Zn, Pb, Ba, Cu, (Sr), (Fe)*	Titanium white and/or zinc white, ultramarine, copper-containing blue[c], iron earth colorants *(titanium white and/or zinc white, lead white, cadmium red/yellow, additional)*
Periwinkle *(orange)*	Ti, Cd, *Zn, Ba, Sr, Fe, (Pb), (Cu), (Mn), (Se), (Cr)*	Ultramarine, copper-containing blue[c], titanium white and/or zinc white[b], iron earth colorants *(cadmium red/yellow, titanium white and/or zinc white, lead white, additional)*
Bold green	Cd, Zn, *Sr, Ba, Ti, Se, Fe, Cu, (Mn), (Pb), (Al)*	Cadmium yellow, copper-containing blue[c] *(zinc white, titanium white, mixed black*[b]*, additional)*

[a] All top layer colors listed have additional paint layers underneath. Underlayer colors were only listed if they could be visually observed through cracks or at the boundary of the color shape.

[b] According to Seckler (1953), Davis preferred a mixture of ultramarine and burnt umber over commercial blacks. "Mixed black" in the table refers to the mixture of these two colors.

[c] According to Seckler (1953), Davis used a phthalocyanine color in *Rapt at Rappaport*. The copper signal could be from a similar color.

information about molecular compounds, was used to further suggest which colorants are present in the top layers. Separating the colorants in the top layers was not only instructive about Davis's materials, it was also a means to better understand intermediate layers by process of elimination. If p-XRF readings contain a signal for zinc but FORS readings do not, the assumption is that zinc is not present at the top, but rather in an intermediate layer, where its degradation could cause the blind cleavage observed in an otherwise robust-looking paint surface.

Using p-XRF data to choose colorants, reference paint-outs were made to match as closely as possible several colors treated for lifting paint, with increasing amounts of zinc white mixed in with the base colorant.[3] The FORS spectrum from the appropriate color on the painting was then compared with the corresponding reference to determine where the color fell in relation to the scaled inclusion of white. In figures 9a and 9b, the bold green that was treated for severe cleavage demonstrates a zinc signal in p-XRF, yet the FORS spectrum is less definitive as to the presence of zinc white. According to the research of Picollo et al (2007), an absorption trough in the region of 370–400 nm is especially characteristic of zinc white. Bearing in mind the signal-to-noise ratio level in this crucial region, the scaled paint-outs' spectra seem to indicate that a lack of FORS response in this region does not necessarily mean zinc is absent from a mixture; it could be present in quantity less than 50% w/w. P-XRF of the paint-outs demonstrated that such quantities of zinc can produce strong signals; however, a correlation between this information and readings from the painting is limited because of the many variables of the original paint's content and the fact that p-XRF is not a quantitative tool. It should also be noted that zinc white has sometimes been included by manufacturers in other white paints for stabilization (Kühn 1986).

Layered paint-outs as well as additional references made from a variety of manufacturers would lend further insight into whether the p-XRF zinc signal could be from minor quantities in the top layer, from an underlayer, and/or whether other commercial paint components suppress signals. For now, this examination with p-XRF and FORS continues to point toward interlayer zinc-containing pigments as a possibility.

3.2.3 Interlayer grime

The 1940s were personally difficult for Davis due to emotional distress and alcohol-related health struggles (Agee 2007), and he produced very little despite receiving a steady increase of professional recognition (Lane 1991). *The Mellow Pad* and its six years of "endless resistance" (Agee 2007, 98) as he put it, probably contributed to his depression as he anguished over composition, color, and his objective visual language (Stuart Davis Papers, Sims 1991). In January of 1947, Davis posed in his studio for a photograph for a *Life Magazine*

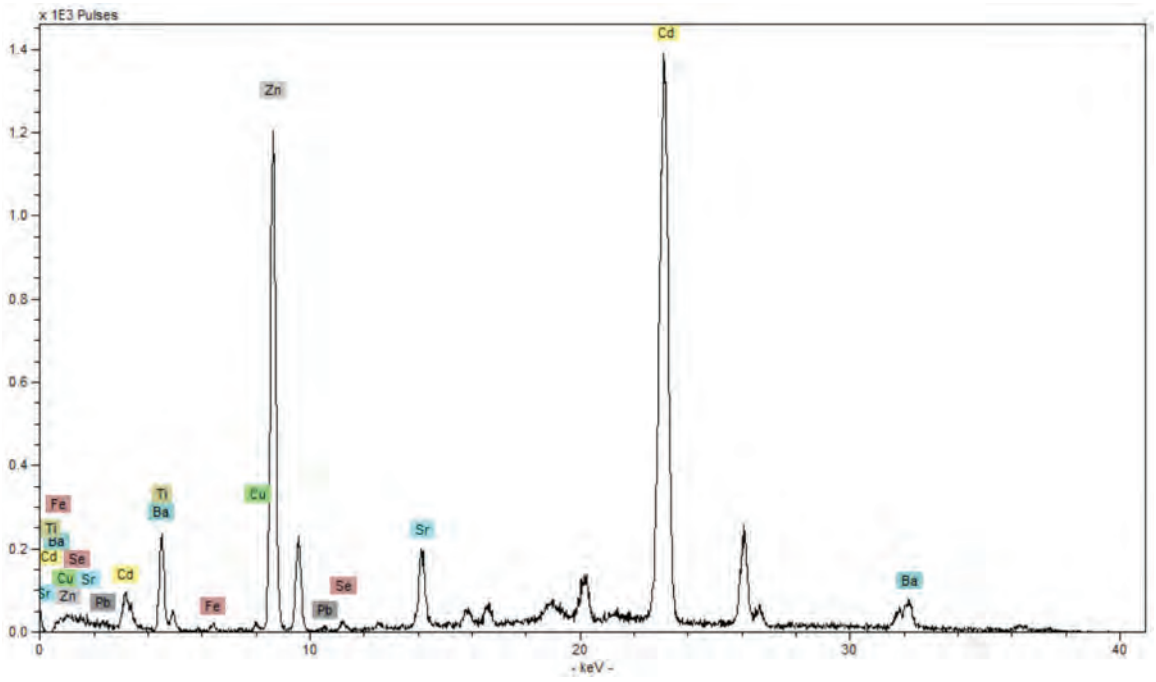
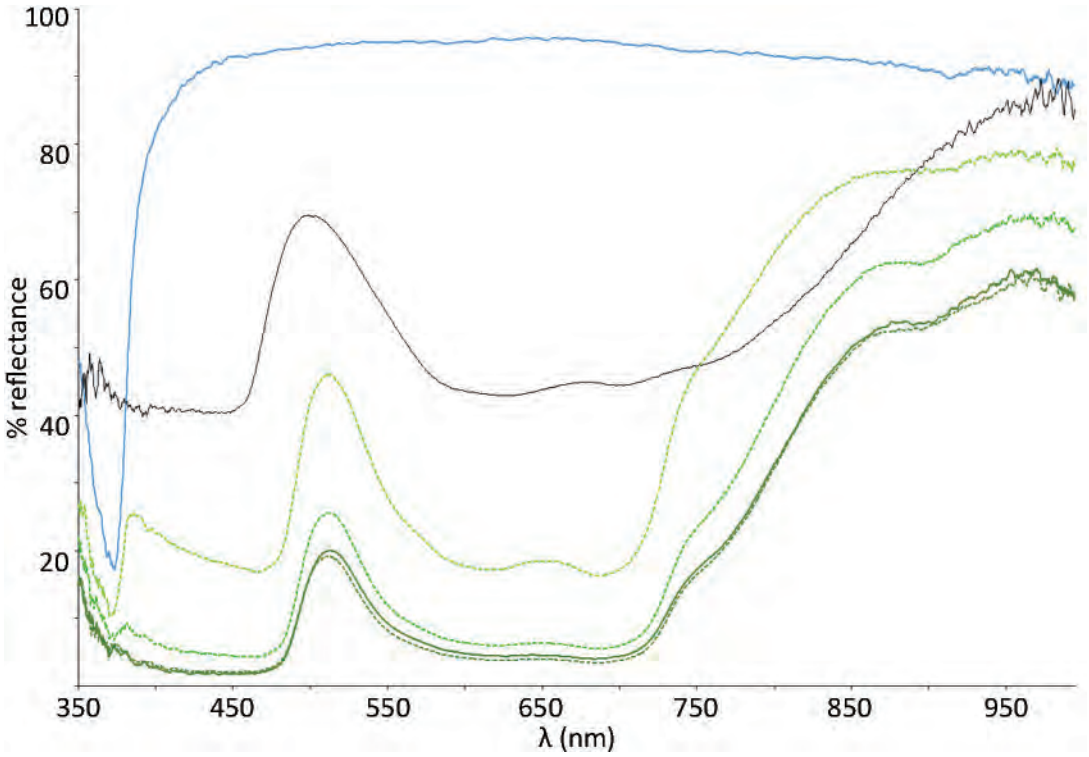


Figure 9. (a) P-XRF spectrum of bold green in the top right quadrant of the painting. Major signals present: Cd, Zn. Minor: Ba, Sr, Ti, Cu, Se, Fe. Trace: Pb, Ca.



(b) FORS spectra of bold green (*black line*, baseline raised to 40% mark for clarity), and reference paint-outs of pure zinc white (*blue line*), and a mixed green (*green lines*). The mixed green reference spectra show 100% green (*dark green solid line*); and green with the addition of 10% w/w zinc white (*dark green dashed line*), 50% w/w zinc white (*medium green dashed line*), and 90% w/w zinc white (*bright green dashed line*). The mixed green reference was made with cadmium yellow, viridian, and phthalo blue, which showed spectral features similar to the bold green on the painting.

article (Sargeant 1947, fig. 10a). In the background of the main image, one can see an early stage of *The Mellow Pad* (fig. 10b). Using this image and other historical documents and paintings as a guide, a rough timeline for the painting's evolution can be constructed.

After completing an initial stage of the painting in 1945, Davis exhibited *The Mellow Pad* twice before bringing it back to the studio for reevaluation (Boyajian and Rutkoski 2007). He made two painted studies in 1946[4] and two more in 1947 along with dozens of sketches (Stuart Davis Papers). In 1949, he was hospitalized due to worsening health, causing another extended pause in work (Agee 2007). His fifth painted study was left unfinished in 1949, but the colors, in particular the pinks, relate closely to some of the final colors applied to *The Mellow Pad*. In 1950, healthier and apparently reinspired, Davis returned to work on *The Mellow Pad* and also began developing a new series of paintings (Agee 2007).

The painting was finally completed in March 1951, after an intense, three-month long effort that included reworking the section he referred to as "Hell's Corners" (fig. 11; Stuart Davis Papers). A quote from his calendar, which he used as a diary, conveys the emotion he intentionally separated from his art: "Worked on Hell's Corners of Mellow Pad with terrific results […] This day was probably the most powerful objective Art realization of my life" (Boyajian and Rutkoski 2007, 360). This extended timeline of paint application spanning from 1945–51 means that the many layers include dirt and grime that interfere with paint adhesion. Supporting this theory, the most densely layered region of the painting corresponds with the primary area of severe flaking initially treated by Volkmer.

3.3 RESULTS AND DISCUSSION: DISCOLORED AREAS

3.3.1 Locations of discoloration

The color that first drew attention during the loan review is a diagonal magenta stripe that crosses a vertical black stripe near the center of the painting: it shifts to a pale, yellowish color only at the intersection with the black (fig. 12). Above the

10a

10b

Figure 10. Stuart Davis in his studio (a), 1947, photographed by Ralph Morse (Sargeant 1947). Detail of *The Mellow Pad* from the photograph (b), adjusted in Photoshop to display the painting at its correct proportion for comparison to its current state.

Figure 11. Stuart Davis, *Study for The Mellow Pad*, 1951. Courtesy of Harvard Art Museums/Fogg Museum, gift of Mrs. Stuart Davis, 1967.79.702.

diagonal stripe, a magenta trapezoid also crosses the black stripe, and it similarly shifts in color only at the intersection (fig. 13). Study of historic photos revealed that not only was the diagonal stripe initially a solid color, but also that additional pinks had changed over time: the nearly white square surrounding the light blue infinity symbol in the lower middle faded from a vibrant pink to the present color, and the upside-down hot pink triangle in the upper left quadrant has selective loss of color at the ridges of brushstrokes (fig. 14).

3.3.2 Layering technique

Davis's approach to layering is key to understanding the magenta discolorations. When he painted *The Mellow Pad*, he essentially laid down each shape as a complete object existing in its own two-dimensional plane. The distinct outlines of shapes, even those obscured or altered by subsequent layers, are visible in the x-ray radiograph (fig. 15). Changes to the composition were made by adding complete shapes on top of previously applied shapes, creating visual depth through the illusion of light filtering between physical sheets of color.

Figure 12. Detail of the discolored magenta stripe. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

Figure 13. Detail of the discolored magenta trapezoid. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

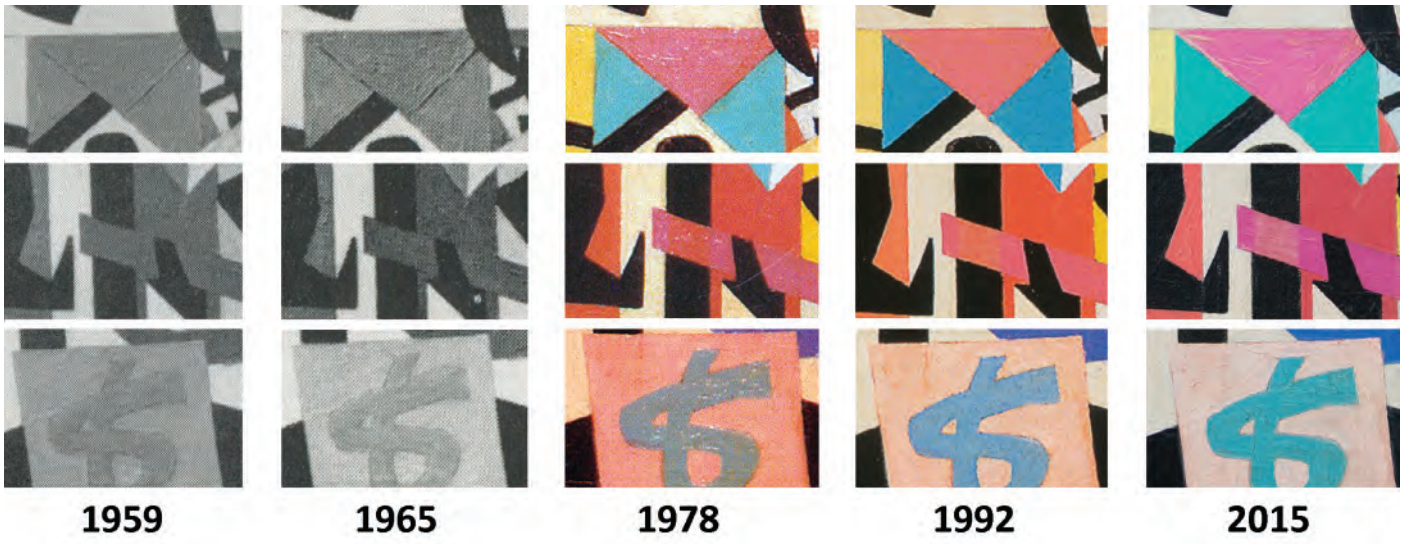


Figure 14. Detail images showing the progression of color changes in three areas (Goossen 1959; National Collection of Fine Arts 1965; Lane 1978; Boyajian and Rutkoski 2007). Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

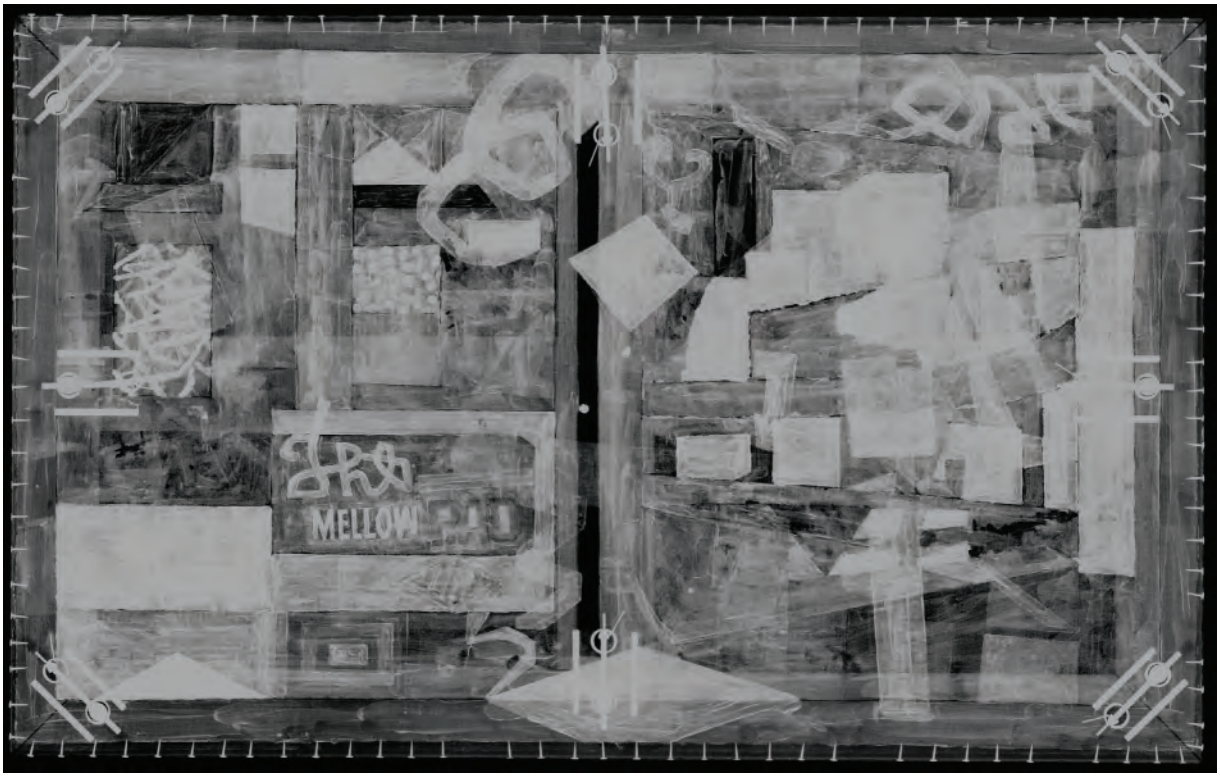


Figure 15. X-ray radiograph. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

Davis would alter colors and patterns as frequently as he added new shapes, changing stripes to solids, shifting a color to its compliment, and often shifting it slightly again (fig. 16), until the area "reached a degree of complexity and completeness satisfactory to the impulse that initiated it" (Davis 1960). He preferred mixing his own colors and did not like using paint straight from the tube (Seckler 1953). After an area was settled, he would reinforce the colors with thicker paint as

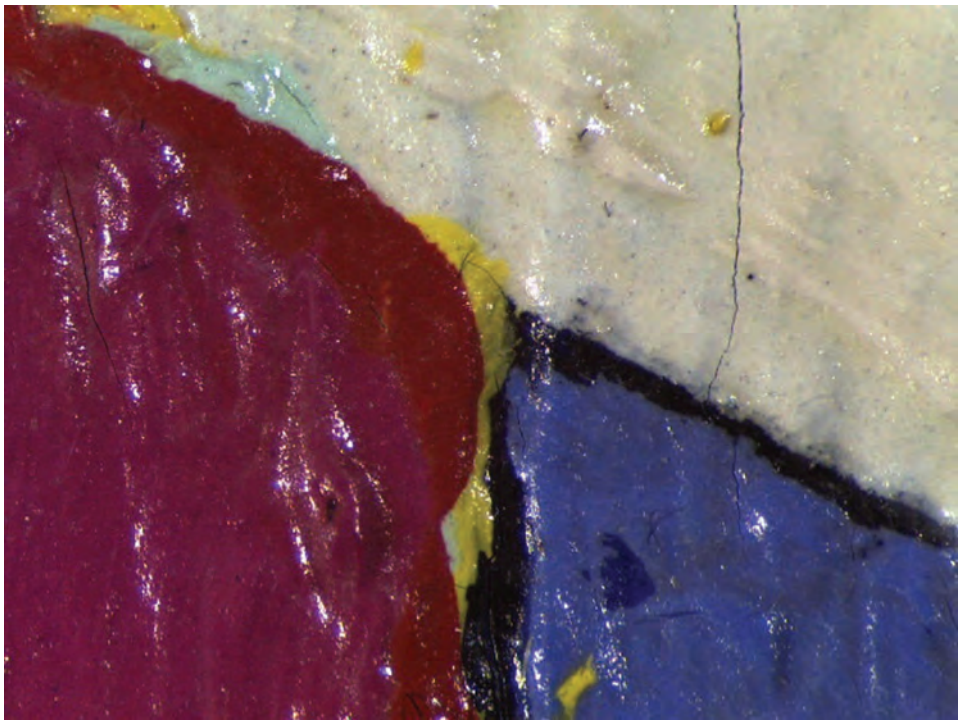


Figure 16. Photomicrograph showing the edges of multiple color layers, 16x. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

Figure 17. Photomicrograph of the "a" in Davis's signature, 8x. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

needed, either across a whole shape or locally. Even his signature is treated as a shape in this way, with a linear charcoal underdrawing, a peach color brush-applied directly on top, and both the positive shape of the signature and the negative around it reinforced with another layer (fig. 17).

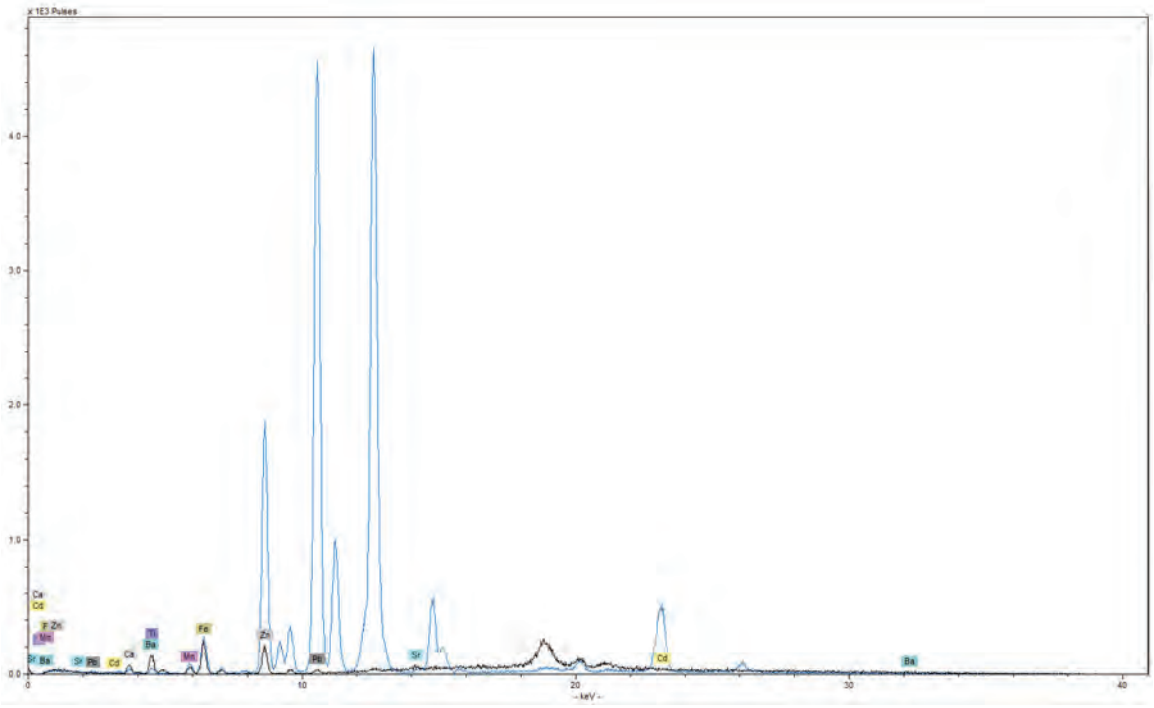
MBI helped illustrate this reworking and layering of the paint within a shape. What appears to be a uniformly yellow passage under normal light (fig. 18a), in the area around the black lattice in the upper left quadrant, is revealed to have two different paint compositions under ultraviolet (UV) illumination due to the contrast between the luminescent yellow visible around the edges and the UV-absorbant yellow applied on top (fig. 18b). Visible-induced luminescence (VIL) imaging further clarifies the paint content (fig. 18c): the bright luminescence around the edges from the lower layer of yellow indicates that the colorant is cadmium sulfide (Van der Snickt et al 2009, Mass et al. 2014). The UV-absorbant top layer, while excellently color-matched and potentially still cadmium containing, exhibits different chemistry and was applied after the lower layer was dry.

3.3.3 Discolored magenta

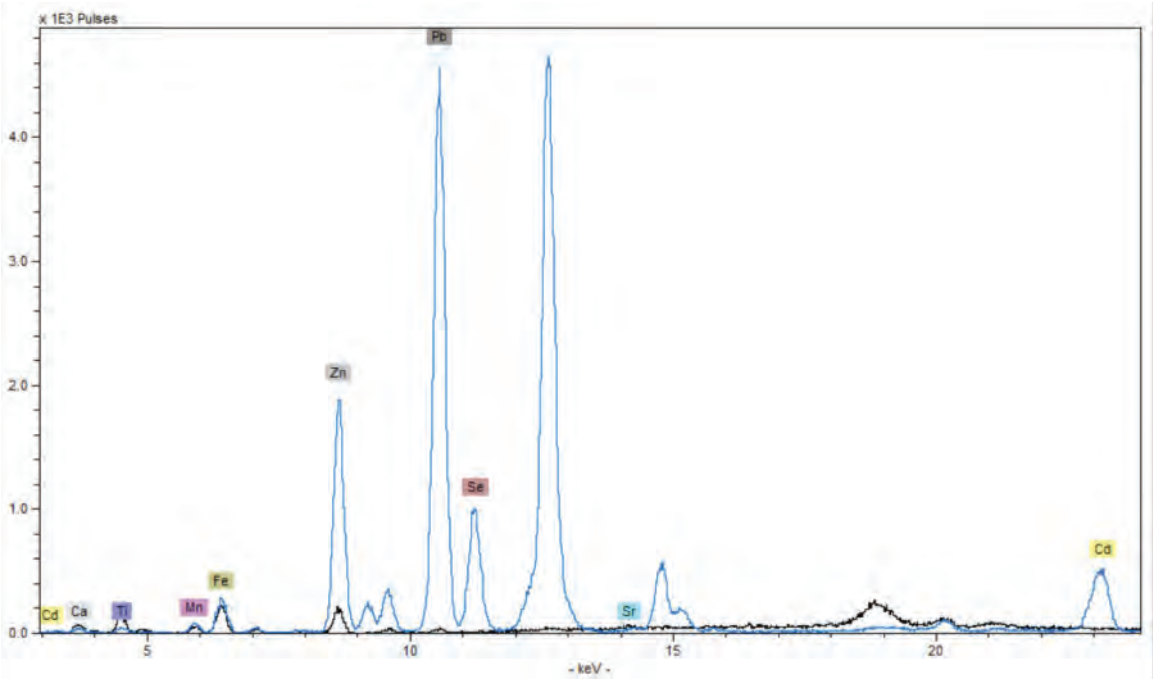
The x-ray radiograph shows that the vertical black stripe was laid down on the gesso priming as one of the initial compositional forms and is one of the few unaltered elements. Most of the black shapes were added later, on top of other colors. P-XRF analysis provides supporting evidence. Most of the canvas surface surrounding the black stripe was painted with abutting lead white-containing shapes that were eventually completely covered: the lead signal throughout the painting has an attenuated L-α signal in relation to the L-β signal, and the inversion of the relative peak heights of these lines increases in sections of thicker paint (McGlinchy 2012). The peak–height relationship was slightly corrected when taking readings of the back of the painting in corresponding locations, indicating that the lead white shapes were applied early, perhaps as part of the completion of the underdrawing. This preliminary lead layer does not exist beneath the black stripe (figs. 19a, 19b). Adapted directly from *House and Street*'s composition, the stripe has been bifurcating the composition since the initial underdrawing stage.

18a 18b 18c

Figure 18. Detail of yellow and black lattice in normal light (a), UV (b), and VIL (c). Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.



19a



19b

Figure 19. P-XRF spectra, at full size (a) and zoomed in for clarity (b), from the vertical black stripe (*black*) and from the black shape in the top right corner (*blue*). Major signals present in the black spectrum: Fe, Mn. Minor: Ti, Zn, Ca. Trace: Sr, Pb, Ba, Cd. Major signals present in the blue spectrum: Pb. Minor: Zn, Fe, Mn, Cd, Se, Ca. Trace: Sr. Note the attenuated signal of the L-α line in relation to the L-β line for lead, even in this relatively thinly painted region.

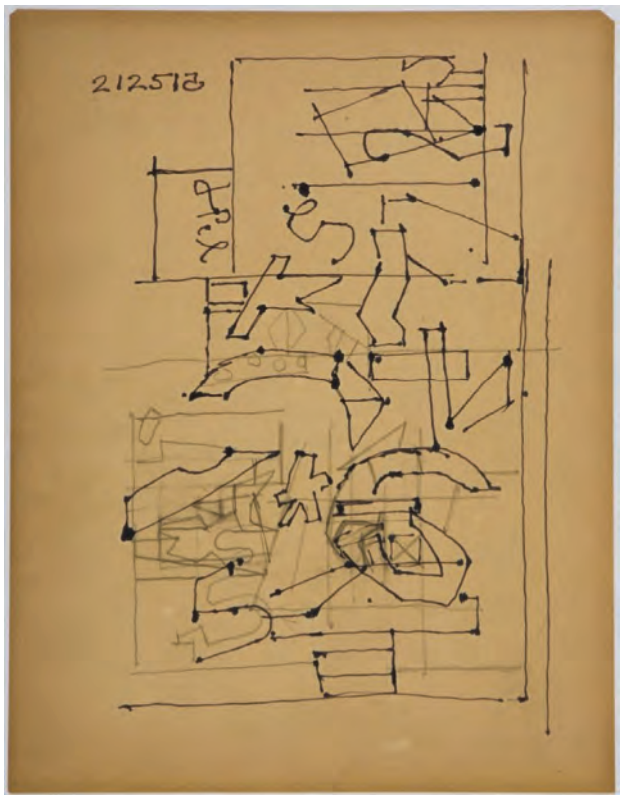


Figure 20. Stuart Davis, *Study for The Mellow Pad*, 1951. Courtesy of Harvard Art Museums/Fogg Museum, gift of Mrs. Stuart Davis, 1967.79.666.

In contrast, the intersecting magenta shapes were applied in the final stages of the painting's evolution. Davis's sketches, available online through Harvard University Libraries, were an invaluable resource in determining the chronology of various shapes. The diagonal stripe first appeared in sketches in 1950 (fig. 20). It was added as a cooler hue first and was later coated with a warmer hue. The rest of the magentas throughout the composition were applied in one layer, including the trapezoid, which was not conceived until 1951 (fig. 21). Reflectance transformation imaging accentuates the continuous brush strokes and paint body across the trapezoid (figs. 22a, 22b), further demonstrating that the magenta shapes were intended to be solid rather than broken up by color at their intersections with the black stripe.

The OCT cross section image provides even more information about these intersecting colors at their boundary line (figs. 23a, 23b). The right side of the cross section shows the magenta paint, which exhibits strong light scattering due to the presence of opaque pigments such as vermilion and cadmium red (table 2). The black stripe has two layers. The upper layer on the left side is black shape-reinforcement paint applied after the magenta stripe was in place. There is some light scattering present in this black paint layer indicating the presence of more than carbon-based materials. Analysis supported reports that Davis favored the mixture of ultramarine blue and burnt umber to make black, because it dried faster than commercial blacks (table 2; Seckler 1953).

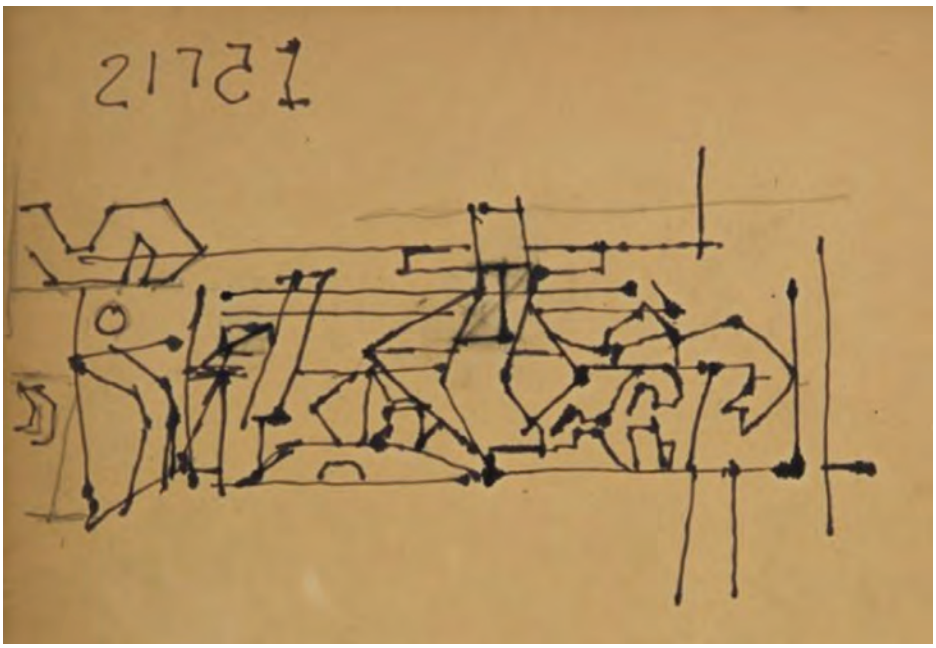
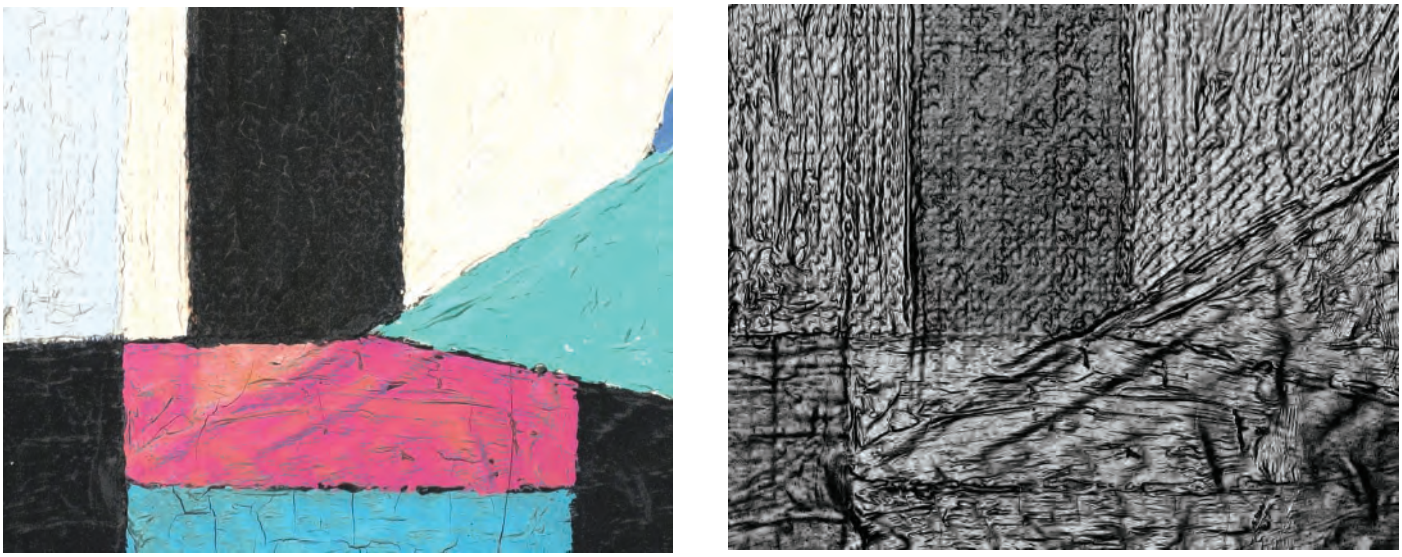


Figure 21. Stuart Davis, *Study for The Mellow Pad*, 1951. Courtesy of Harvard Art Museums/Fogg Museum, gift of Mrs. Stuart Davis, 1967.79.701.



22a 22b

Figure 22. RTI detail images of the magenta trapezoid, unenhanced (a) and with specular enhancement (b). Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

The original layer of the black stripe is visible in the low-lying boundary between the black and the magenta paints. Compared to the upper black paint layer, the layer within the boundary is composed of materials that are distinctively more NIR-absorbant. This feature combined with the grainy surface texture indicates that the lower layer is composed primarily of charcoal. Under UV illumination, the boundary surface shows a brighter yellow luminescence (fig. 24). The evidence is consistent with the description of Davis's working process for *Rapt at Rappaport*, of completing the underdrawing in

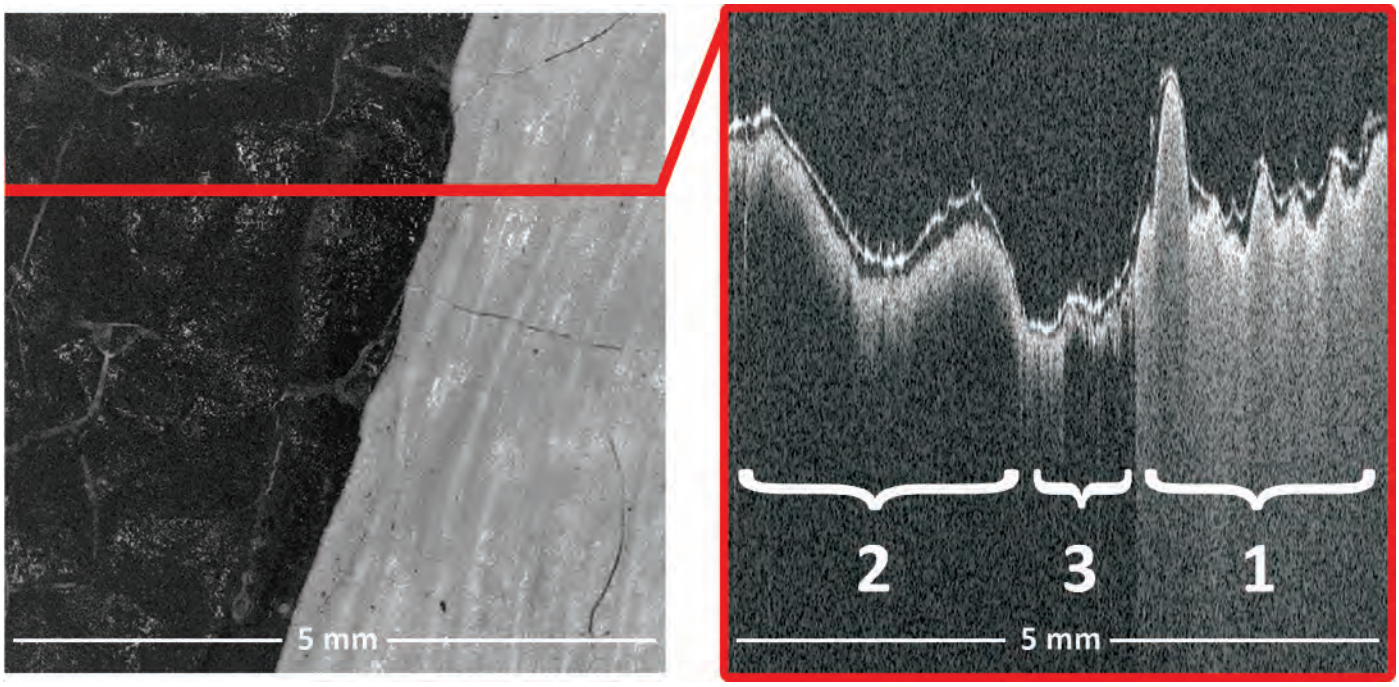


Figure 23. The scanned area (a) yielded the OCT cross section (b). In the cross section, the numbered regions can be described: 1. Magenta paint with high scattering. 2. Black paint with some scattering at the surface. 3. Charcoal layer visible between the boundaries of magenta and black paint.

Table 2. Summary of p-XRF results for pinks and blacks

Top layer color *(observed underlayer(s))*[a]	p-XRF Major, *Minor*, *(Trace)*	Top layer colorants likely *(Underlayer colorants likely)*
Magenta stripe[b] *(white)*	Ti, Pb, Zn, *Ca, Ba, Fe, Sr, Se, Cd, (Hg), (Mn), (Al)*	Titanium white, red lake, vermilion, cadmium red, organic colorants *(zinc white, titanium white, lead white, iron earth colorants)*
Magenta stripe – discoloration[b] *(black)*	Ti, *Zn, Ca, Fe, Hg, Mn, Al, Ba, Pb, Se, Cd, (Sr)*	Titanium white, red lake, vermilion, cadmium red, organic colorants *(mixed black[c])*
Faded pink square[b] *(pink, orange, red, light blue)*	Ti, *Zn, Fe, Mn, Ca, Hg, (Cd), (Sr), (Pb), (Al)*	Titanium white and/or zinc white, organic colorants, iron earth colorants *(lead white, vermilion, earth colors)*
Hot pink triangle[b] *(red)*	Ti, Cd, Se, *Zn, Pb, Ca, Fe, Sr, (Ba)*	Titanium white and/or zinc white, red lake, cadmium red, organic colorants *(cadmium red, lead white)*
Hot pink triangle – discoloration[b] *(red)*	Ti, Cd, Se, *Zn, Pb, Ca, Fe, Sr, (Ba)*	Titanium white and/or zinc white, faded red lake, cadmium red, organic colorants *(cadmium red, lead white)*
Black – top right corner *(light pink)*	Pb, *Fe, Mn, Zn, Cd, Se, Ca, (Sr)*	Mixed black[c] *(lead white, zinc white, titanium white, cadmium red)*
Black stripe	Fe, Mn, *Ca, Zn, Ti, (Pb), (Sr), (Ba), (Cd)*	Mixed black[c] *(priming)*

[a] All top layer colors listed have additional paint layers underneath. Underlayer colors were only listed if they could be visually observed through cracks or at the boundary of the color shape.
[b] Readings were taken both with and without a vacuum attachment.
[c] According to Seckler (1953), Davis preferred a mixture of ultramarine and burnt umber over commercial blacks. "Mixed black" in the table refers to the mixture of these two colors.

charcoal and setting it with a (presumed) resinous turpentine (Seckler 1953). It seems possible that the acidic nature of an unrefined natural resin sealant, aged for a few years, catalyzed the degradation of a sensitive magenta paint applied directly on top. Heat from the lining treatment may have enhanced any such effect.

Figure 24. Detail of boundary (indicated with red arrow) between magenta stripe and black paint applied on top of black stripe, under UV illumination. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

3.3.4 Faded pinks

The other two pink areas in question appear to have faded because of the presence of fugitive organic dyes, either overall in the case of the square or selectively in the case of the triangle. Davis's approach to palette preparation provides some insight into the selectiveness of the triangle's fading, and into the relationship between all of the pink discolorations.

Each time Davis sat down to paint, he mixed all of the colors he planned to use (Seckler 1953). On the basis of sketches (fig. 25), the square around the infinity symbol was first added in 1950 using a vibrant pink paint that can be observed through tiny holidays in the top surface (fig. 26). In a later campaign, Davis added the top layer colored exclusively with fugitive organic dyes (table 2). The palette of colors mixed for this campaign must have included the color for the cool, lower layer of the diagonal magenta stripe. Davis seems to have used a combination of this cool magenta of the stripe, the fugitive paint of the square, and some extra white to transform the formerly cadmium red upside-down triangle into a hot pink one. Whether Davis intentionally included the fugitive color in the mixture for the triangle is unclear, since it only discolors at the ridges.

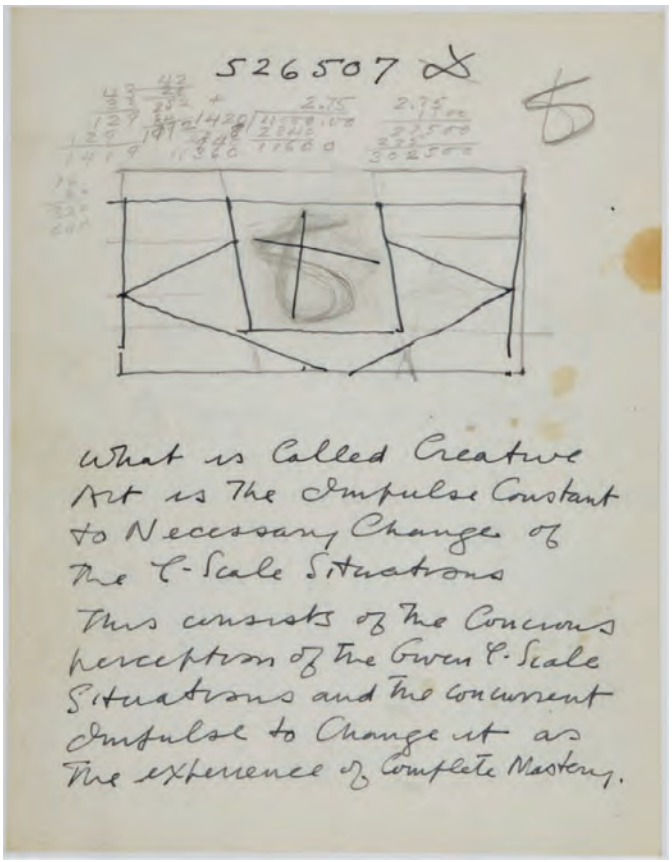


Figure 25. Stuart Davis, *Study for The Mellow Pad*, 1950. Courtesy of Harvard Art Museums/Fogg Museum, gift of Mrs. Stuart Davis.

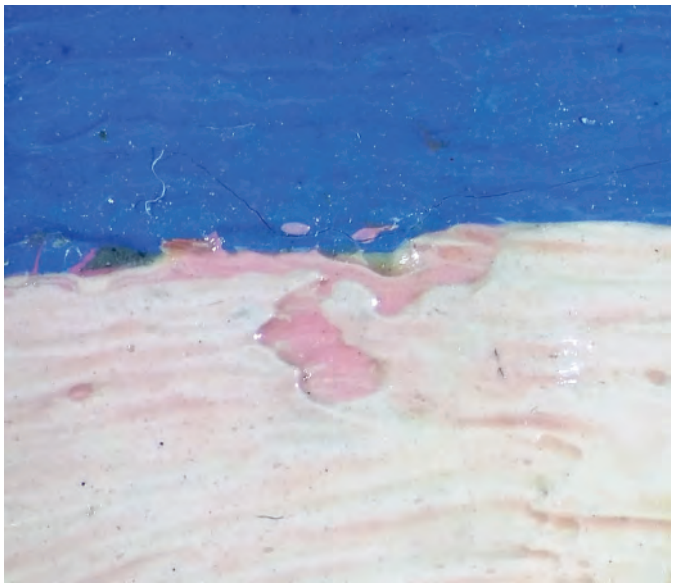


Figure 26. Photomicrograph showing intact pink paint beneath the faded upper layer, 16x. Stuart Davis, *The Mellow Pad*. Courtesy of Brooklyn Museum, bequest of Edith and Milton Lowenthal, 1992.11.6.

Davis often mixed his palettes while watching TV (Seckler 1953). As meticulous as he was in his paint application, it is tempting to speculate that he may have been distracted when it came to thoroughly mixing colors and cleaning his brush.

4. CONCLUSION AND FURTHER STUDY

Thanks to the Bank of America Art Conservation Project, the Brooklyn Museum Conservation Department had the privilege of giving in-depth attention to a beloved collection object. *The Mellow Pad* was successfully stabilized for display. The technical study provided overall image maps for comparison and spot analysis for approximately 50 locations to clarify materials and technique. In conjunction with historical documents, this data is especially useful for understanding this painting's unique creation process, and, inherently linked to this, the causes for interlayer cleavage and odd discolorations. Investigation suggested that underlying chalk, zinc-containing pigments, and interlayer grime all contribute to inherent, extensive lifting paint in *The Mellow Pad*. Areas of selectively discolored magenta appear to be caused by a chemical reaction with the underlying layer, and a loss of pink coloration in other areas was caused by fugitive organic dyes.

Yet, this research has only scratched the surface of the wealth of technical and artistic history unleashed by this innovative artist. The numerous layers of mixed paint colors limited confident identification of colorants using noninvasive methods only, and additional questions remain about paint manufacture and potential nontraditional media. Directed by noninvasive analysis, a small number of microscopic samples were removed for further investigation of the paint media, particularly seeking details about the discolored magenta.[5] There is also more potential for study using FORS. Additional reference paint-outs of complex mixtures and layered colors may further refine the understanding of many colors. Also, FORS provides a means of monitoring any potential color changes in the future, with the currently vibrant magenta and cadmium yellows being of particular interest.

Beyond these planned future studies for *The Mellow Pad*, it is hoped that Stuart Davis's artwork is the subject of many more fruitful research projects and collaborations.

ACKNOWLEDGMENTS

The Brooklyn Museum Conservation Department is grateful to Bank of America for its support of this study, including the acquisition of game-changing noninvasive analytical equipment and the new collaboration with NTU colleagues.

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APPENDIX

Photomicrographs were taken using a Leica M80 stereo microscope with 1C80 HD video output and LED 5000 SLI fiber optic illumination. A Samsung Galaxy S5 was also used to take images through the microscope oculars.

P-XRF readings were taken with a Bruker-Tracer III-V+ instrument with a rhodium source, beryllium sample window roughly 3 × 4 mm in size, and a Si-Pin detector. Settings were 40kV 3mA 60sec. Spectral data were acquired and interpreted using S1pXRF and Artax softwares.

X-ray radiographs were taken using the Vidisco RayzorFox direct capture system with a GE Inspection Technologies ERESCO 65MF3 x-ray tube with digital control, tungsten source, and 300kV nominal voltage. Images were captured using a Vidisco, Ltd., foX-Rayzor digital capture plate and Vidisco X-Bit Pro software. Piece was imaged at 30kV, 4mA for 10 seconds. Images were processed and knitted using Adobe® Photoshop® software.

The CHARISMA Manual developed by the British Museum (Dyer, Verri, and Cupitt. 2013) was the basis for equipment purchases and protocols for MBI. Images were taken with a modified Nikon D6100 DSLR (IR/UV filters removed). Visible images were taken with an IDAS-UIBAR filter (375–700 nm bandpass) attached to the lens, illuminated with Genaray SpectroLED-14 lights (output: 5600k). UV images were taken using UV Systems LW370 TripleBright II lights (output 368 nm, 5750k). UV luminescence images use an IDAS-UIBAR filter and a Kodak 2E pale yellow optical wratten filter (410 nm longpass). UV reflectance images use an X-Nite BP1 (320–670 nm bandpass) and X-Nite 330 filter (270–375 nm bandpass). IR images were taken using mounted lights in imaging area, with an X-Nite 830 filter (830 nm longpass) attached to the lens. VIL images were also taken with X-Nite 830 filter, using American DJ RGB LEDs.

RTI was performed using a modified Nikon D610 DSLR (IR/UV filters removed) with an IDAS-UIBAR filter (375–700 nm bandpass) attached to the lens, with a Nikon SB-910 AF Speedlight and Nikon SU-800 Wireless Speedlight Commander Unit.

FORS readings were taken using an Ocean Optics FLAME-S-UV-VIS-ES spectrometer, with optical resolution (FWHM) of ~1.5 nm in the range of 400–1000 nm, recorded using OceanView software.

NOTES

1. Although many resources are available that discuss Stuart Davis's art theories, compositions, and general approach, very few go into detail about the artist's painting technique and materials (Seckler 1953, Davis 1960, Boyajian and Rutkoski 2007).
2. Previous adhesives used include PVA-AYAA, wax-resin (unspecified), BEVA® 371, Paraloid® B-72, and Lascaux Acrylic Adhesive 498HV.
3. Paint-outs for select colors were made in house using dry pigments in linseed oil, and also Grumbacher Academy Oil Colors. The CNR-IFAC (2011) spectral database was used as a supplementary reference.
4. The oil paint studies are located in the following collections: *Pad #1*, Honolulu Academy of Arts; *Pad #2*, private collection; *Pad #3*, private collection; *Pad #4*, Brooklyn Museum; and *Pad #5*, last listed in the collection of Sid Deutsch Gallery (Boyajian and Rutkoski 2007).
5. Invasive analysis techniques were completed by Art Analysis and Research in 2017.

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JESSICA VEEVERS

The Autopoiesis of Acrylic Paint and Monochrome Painting in Montreal

ABSTRACT

The object of art, according to anthropologist Tim Ingold, is an emergent autopoietic phenomenon of an unfolding. Autopoietic form does not issue from idea, "rather [it] comes into being through the gradual unfolding of that field of forces set up through the active and sensuous engagement of practitioner and material" (Ingold 1990, 84). In short, things are not the product of artistic intentions, but instead a contingent collaboration between artistic intention and material forces. What comes first? Neither. They evolve together. Acrylic paint has a material will, a specificity, and an elaborative potential that has enabled generations of artists to create in ways that no other medium would allow. This article focuses on one iteration of acrylic paint – that produced by the Montreal-based acrylic paint manufacturing company, Chromatech (1978 and 1999), and used by Quebecois monochrome painters, Guido Molinari, Claude Tousignant, Yves Gaucher, Guy Pellerin, and Christian Kiopini. It documents the mutual evolution between acrylic paint and monochrome painting. One would not exist without the other.

1. INTRODUCTION

This article looks at the intersection of acrylic paint and monochrome painting during the second half of the 20th century in Montreal. It discusses the period spanning the adoption of acrylic paint up until our contemporary period, but focuses on the relationship between the artist-run paint manufacturing company, Chromatech Acrylic Paint owned and operated by Michael Towe, and Montreal post-Plasticiens Guido Molinari, Claude Tousignant, and Yves Gaucher. Molinari is best known for his stripe paintings (1960s), Tousignant for his gong paintings (late 1960s), and Gaucher for his gray-on-gray paintings (late 1960s). All of these series were done in the early Liquitex formulation; Chromatech did not exist yet.

The materialization of the monochrome is best described as autopoietic because its emergence was not specifically willed but came from within a field of forces that consisted of a backlash against traditional art figuration and narratives, groups of young artists experiencing the post-war freedoms and driven to find new meaning for their production, an art criticism that embraced the avant-garde and abstract art, and the industrial revolution driving expansion and decoration, which in turn drove paint manufacture to new expressions (such as house paints and car enamels), greater quantities, and broader availability. All of these things created for the open-minded and fast experimentation that characterized, and still characterizes, many would argue, late modern and early contemporary art making. Anthropologist Tim Ingold explains that autopoietic form "comes into being through the gradual unfolding of that field of forces set up through the active and sensuous engagement of practitioner and material" (1990, 84).

Autopoiesis involves an automatic growing from within and accentuates that everything together—the ideas, the culture, the artists, and the acrylic paint—made for the perfect monochrome painting incubator. This emphasis is important not because artists found paint that suited ideas they already had or because it was, as the influential American art critic Clement Greenberg maintained, an inevitable result of the "general tendency" in modernism (1993, 85), it was also because acrylic paint was generative. Artists believed that acrylic paint was the way of the future. They thought it was more stable and colorfast and its unique material properties allowed them large-scale evenness and multilayering potentiality that would have been impossible with oil or synthetic resins. The artist Otto Rogers, one of the earliest Canadian adopters of acrylic paint, reflects that "acrylic paint is very mysteriously wrapped into what is possible to make high art" (April 18, 2016).

2. ART HISTORICAL INFLUENCE

The influence of art historical traditions and modernist art criticism were pushing for novelty and purification: artists wanted to move away from the traditional academy and critics like Clement Greenberg were charging artists with the responsibility that good art must be avant-garde and must therefore be innovative (1993, 8:18). Acrylic paint allowed painters a material expression that created a definitive break with earlier painting. Acrylic paint was the vocabulary the post-Plasticiens needed. Although the post-Plasticiens were more influenced by the European tradition, like the paintings of Piet Mondrian and semiotic theory, and were opposed to a number of Greenberg's modernist criteria, they were certainly feeling the modernist push to find the mode and the material that resonated with their energy. Both Jack Bush and Art McKay benefitted from the guidance of Greenberg, however. Greenberg visited Jack Bush's studio in Toronto in 1957; Bush is now one of the best-known abstract painters in Canada. Greenberg praised Art McKay's paint handling during the 1962 Emma Lake workshop in Regina. McKay continued using latex and stovepipe enamel throughout the 1960s. The influence of art criticism and New York painting was strong in Canada.

3. MATERIAL EXPERIMENTATION

The first monochrome documented in Quebec was done as early as 1956 by Claude Tousignant, but it was not until the early 1960s and with the adoption of acrylic paint that the monochrome-style abstract painting as we know it today became a mode of expression for the post-Plasticien Quebec artists. Tousignant's *Monochrome Orangé* was painted during his first solo exhibition at Galerie l'Actuelle in Montreal (Lanctôt 2009, 207). He used the car enamel Cilux on linen canvas and achieved an extremely high gloss and smooth surface. The original painting was lost around 1991–1992 during transport to the National Gallery of Canada, and the artist made a copy in 1969; the verso was dated 1956 (1969).[1] However, Mark Lanctôt writes that the painting was exhibited for the first time in the 1967 *Peinture Québécoise* in Montreal's International and Universal Exposition (2009, 207), so it must have been repainted before 1969 or it was repainted more than once. Molinari was the first to use car paint enamel in 1955. He visited New York in 1955 with his partner Fernande Saint-Martin; they toured many galleries while they were there and Gilles Daigneault of the Molinari Foundation believes that Molinari saw Duco being used and probably brought Duco back with him on this trip (April 28, 2016). Tousignant started using Cilco and Cilux shortly after this. These are car enamels made by the Canadian company CIL, which he acquired from a store on Saint Denis Street. The store has since closed down (Tousignant August 20, 2015). The post-Plasticien explains that he was looking for something to dry quickly and that Cilco and Cilux were still too slow. Former National Gallery of Canada curator Denise Leclerc further qualifies that the artists were attracted to the car paints because of the saturated colors they produced. They were trying to get away from the illusion of space – an intensely shiny surface that reflected back at the perceiving viewer allowed them to do so (Leclerc April 4, 2016). Tousignant and Molinari began using masking tape because it was included in the kit with the car paint (Leclerc 1991, 191).

And the masking tape stuck. Both Tousignant, who began using Liquitex acrylic paint in 1958, and Monlinari, who first adopted it in 1957, continued using masking tape to achieve crisp edges (Tousignant August 20, 2016). Molinari referred to this fastidious technique as "razor-edge" (Sandals 2013). Unmodulated color and razor-edges are defining characteristics of the post-Plasticiens Molinari, Tousignant, and Gaucher. It is what sets their painting apart from their New York-based contemporaries (Sandals 2013) like Rothko, Noland, Newman, and Olitski, whose edges are a bit softer and often bleed or blend into one another.

When asked, Tousignant explained that he was drawn to acrylics for three reasons: (1) they dried quickly, (2) their color does not change, and (3) they remain stable (August 20, 2015). Compared with oil paint that dries slowly, yellows with time, and sometimes cracks and their unsatisfactory experiments with car enamel, which were characterized by noxious off gassing, all of their paintings cracking very badly, and many being destroyed (Tousignant August 20, 2016; Gaigneult April 28, 2016), acrylic paint offered the perfect technical solution and the bright colors these painters were after. The consistent report from painters is that acrylic paint was more reliably permanent than oil paint. They thought they could trust the medium and that the colors would not change. Henry Saxe, Claude Tousignant, Otto Rogers, Guy Pellerin, Christian Kiopini – all of these early adopters of acrylic paint claim the same thing. Looking back on the place of acrylic paint in late modern and contemporary art, the Saskatchewan painter, Otto Rogers, reflects: "Modernism is a quickness, it is about being on the edge, at the avant-garde. You can't speed up oil but you can speed up acrylic and sometimes too fast (April 18, 2016)." The achievements of Molinari, Tousignant, and Gaucher with acrylic paint securely placed them at the avant-garde. Their New York-based colleagues at the time were working much more thinly: they were staining, dripping, pouring, and spraying and using oil, acrylic resins, alkyds, and magna. Many were using acrylic of course but not like the post-Plasticiens. Plastics were modern, and they were the future. These artists believed they could trust manufacturers and put a lot of faith in their guarantees (Rogers April 18, 2016; Saxe March 29, 2016).[2]

The pressure for innovation combined with the ready availability of commercial products led artists who could not afford artist-quality acrylic paint to make their own. Henry Saxe and Jacques Hurtubise would buy bags of vinyl acetate resin from a chemical place in the west end of Montreal and acetone in big gallons, wholesale from Hoechst chemicals, also in Montreal. They would add diethylene glycol monoethyl ether to slow down the evaporation process and mix all of this together in an enclosed room. The whole process was rather dangerous, but for Saxe, the promise of plastic played true; all of his PVA paintings from 1961–1964 remain in good condition (Saxe March 29, 2016).[3]

4. CHROMATECH ACRYLIC PAINTS (1978–1999)

Towe's impact is significant. Would artists have acquired acrylic paint elsewhere? Certainly, but they did not have to because he made good quality paint in large quantities and delivered it to the artists' studios. Having closed down his business well over a decade ago, Towe is uniquely willing and able to provide proprietary information that is usually closely guarded by paint manufacturers. It is a novel opportunity for collecting conservation information. A large cohort of acrylic paintings were executed in Chromatech acrylic paint between the years 1978 and 1999. With the chemical information that Towe is willing to provide, it will be possible to work backwards to determine which additives were used in which paintings and as the effects of age begin to make their mark, there will be clues as to why things are happening. He was the only one producing artist-quality acrylic paint by the gallon in Montreal during the 1980s and early 1990s, and artists would come from all over Quebec to get it.

Figure 1. Michael Towe of Chromatech Arcylic Paint in his current Montreal studio flipping through one of his two large formula binders, 28 April 2016.

Flipping through one of his two three-inch formula binders (fig. 1), looking for the dark blue formula he made for Claude Tousignant's trip to La Rochelle, France, Towe explains Chromatech Paints' higher pigment load is what distinguishes it from other acrylic paint (2015). This quality meant that when artists mixed and added matte or gloss mediums to their mixtures, they diluted *toward* maximum brightness. According to Towe, when commercial colors are mixed or diluted, artists are always moving away from maximum brightness and this is why his paints were of higher quality than other acrylics on the market at the time (June 10, 2015).

Towe launched Chromatech Paints in 1978 (fig. 2) in a second-floor studio apartment on de la Gauchetière in Montreal. The first formula that Towe tried to make was Titanium white in January 27, 1979, but he finally got it only five years later (July 2, 2015). He started with the Rhoplex acrylic polymers AC 33. This was a very early acrylic polymer, and Towe found that it yellowed and hazed significantly in a relatively short time. He experimented with A&E 328 for about a year with a few of his colors, but he found this polymer to be too soft. He would test the films by pouring a thin layer into a small disc-shaped mold, allow them to set, and then place them in the window of his atelier to accelerate their aging. He would check on the progress of the films regularly and made his polymer selections based on which film remained clear and hard. Next, he tried AC 234. He observed that while this film remained quite clear, it was too soft. He ended up using AC 64 in his formulation, which he describes as being quite hard and that was what he wanted. Kate Helwig and Marie-Chantale Poisson found in their 2004 study of Yves Gaucher's paint materials that Towe mixed AC 64 and AC 33 between 1984 and 1985 and by 1986 began using only AC 64, which later became AC 264 in the 1990s (Helwig and Poisson, 2004). The AC 264 was supposedly more advanced, but Towe is not sure if it was as good as the AC 64 for his purposes anyway.

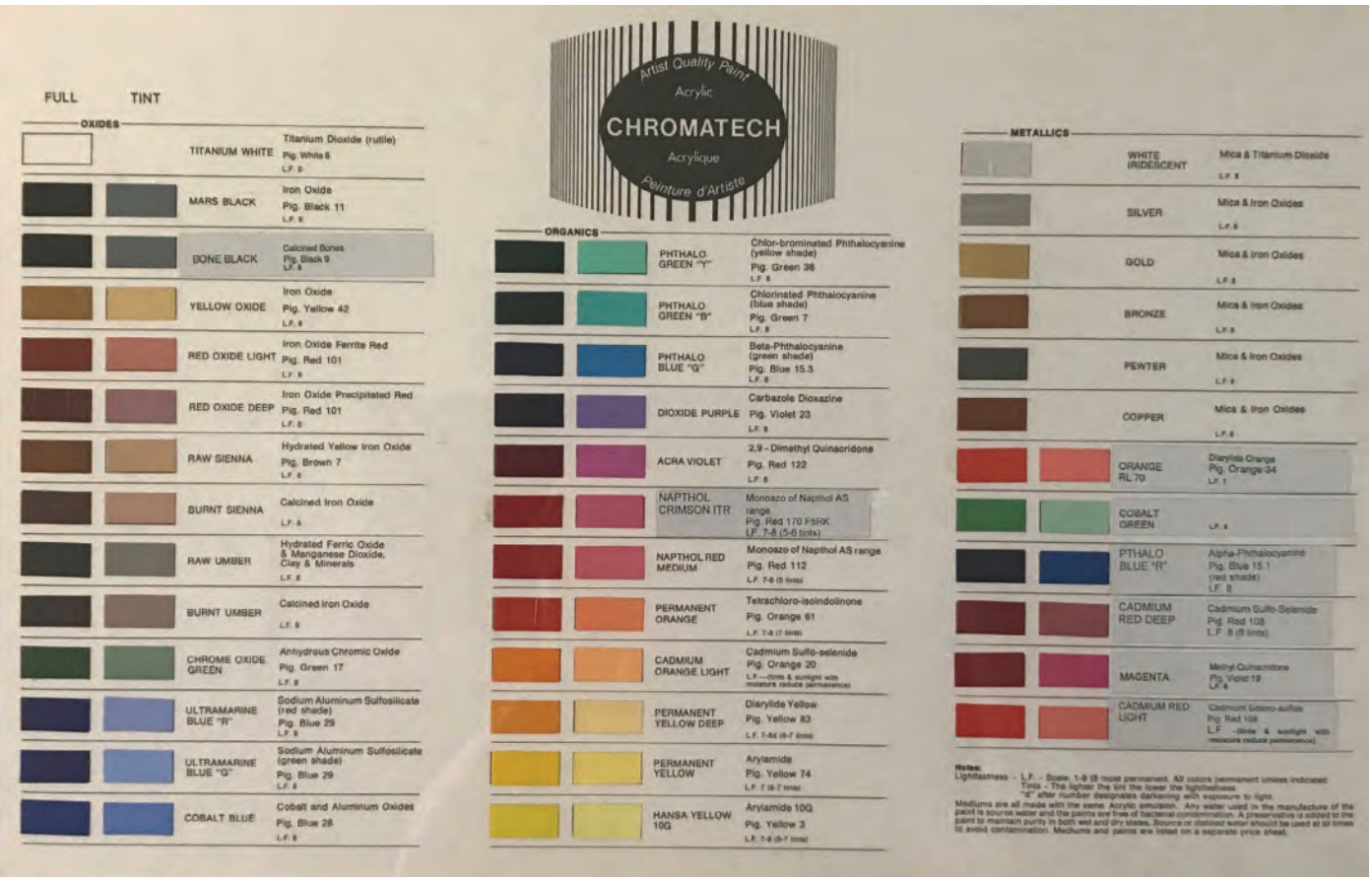

Figure 2. Chromatech Acrylic Paint formula brochure. Each color block was handpainted by Towe to ensure accurate color advertisement.

The additives in Towe's paint include Texanol, a coalescent that makes for better film formation (but will evolve out of the film eventually causing slight film shrinkage); amino methyl propanol 95 (AMP95), a buffer that resists changes in pH; CF-10, a surfactant made by Dow; a defoamer; and a preservative. He stopped using the Montreal water and switched to source water almost immediately. Tap water would rot the paint, and he needed to ensure his product would not mold. Towe did not like that with Texanol the film shrank with time, which in turn caused color change. So he found a better coalescent, Methyl Carbitol, which was superior because it would evolve out of the paint film very quickly. Towe discovered Methyl Carbitol by looking at the boiling temperatures of the different coalescents and determined that the lower the boiling temperature the quicker they evaporated. Methyl Carbitol has a boiling point of 194°C (Dow Chemical 2016) versus Texanol's 254°C (Eastman Texanol 2016). According to Towe film shrinkage is a far bigger issue than slight yellowing with regard to the color stability of acrylic medium. The shrinking will increase the density and an appearance of darkening more than yellowing will (Towe April 28, 2016).

Chromatech's "big break" occurred in 1980 when the Quebec government sponsored a group of Montreal artists to attend a symposium on contemporary painting in Quebec, which was organized by le Musée du Nouveau-Monde in La Rochelle, France. These artists included Guy Molinari, Claude Tousignant, Christian Kiopini, Luc Béland, and Lucio de Heusch. Both Molinari and Tousignant requested specific colors for this enterprise. In an interview, Tousignant confirmed that all of the paints arrived in good condition and that the only issue was that the large 10 x 12 ft. box they were in was secured with square head screws, and they only had a star head screwdriver (September 10, 2015).

In his studio, Towe has two three-inch binders packed with the numerous formulas he created during his 20 years of business. While flipping through these binders, Towe pointed out the specific recipes that he made for Tousignant, Monlinari, Gaucher, and Kiopini. The list of the artists and paint that went to la Rochelle and the specialty recipe that Towe made for Molinari are shown in Figures 3 and 4. Molinari wanted a Payne's Gray that included iron oxide,

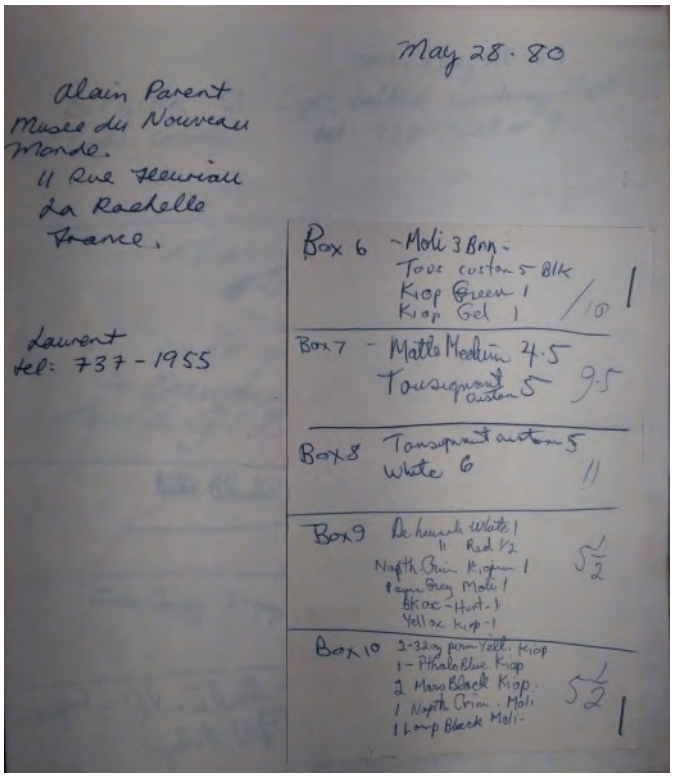

Figure 3. Image detailing the acrylic paint and corresponding artist that Michael Towe prepared and shipped to La Rochelle, France, in 1980.

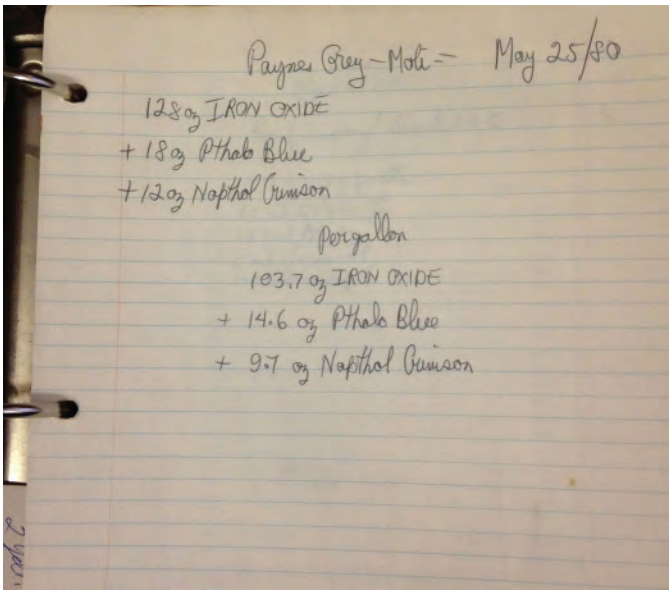

Figure 4. Formula for Payne's Gray that Towe prepared for Molinari and shipped to La Rochelle, France in 1980.

Phthalo Blue and Napthol Crimson. Tousignant requested the darkest blue possible without it being black. The recipe included Napthol Crimson, Iron Oxide Black, Lamp Black and Phthalocyanine Blue. These acrylics were formulated with AC 33.

In an interview, Christian Kiopini remarked that "everyone was using Chromatech, it was in the air" (October 26, 2015). Kiopini started using Chromatech around 1979 and still has some Chromatech paint that he uses. Guy Pellerin recalls that "using Chromatech was like running a luxury car" (September 15, 2015). The paints were so saturated that he needed to add only a small amount of pigment to the gel matte medium to get the color he wanted (Pellerin September 15, 2015). A number of American artists also used Chromatech paint, including Elaine de Kooing and Kenneth Noland. Towe remembers delivering an order to De Kooning's home in the Hamptons shortly after she had returned from a trip to the Lascaux caves in France; she immediately opened her new paints and started painting buffalo. Elaine De Kooning liked Towe's paints and encouraged him to set up his business in the Hamptons to serve the art community there. While intrigued, this type of business expansion was not in the cards for the small company at that time (Towe June 10, 2015). Towe met Noland at the artist's 1987 opening at Galerie Don Stewart in Montreal and sold him a few gallons of Acra Violet, Red 122. He later delivered the paint to Noland's studio in Connecticut (Towe April 28, 2016).

Having worked with some of the Montreal painters through a significant portion of their careers, Towe came to know quite a bit about their techniques. For instance, according to Towe, Tousignant would clean his paintings with Vim when they were dirty. He would dampen a cloth and wipe them down. This method would take a bit of the paint layer with it (Towe June 10, 2015). Gaucher in particular requested a number of different mediums from Towe to achieve the matte-surface quality he needed, and the paint maker in turn came to learn a lot about his process. For Gaucher to arrive at the color he wanted, a strategic method of building was involved.

> He might be looking for a particular red…he would start with the one that he had and then maybe add a layer of blue to push it back a little bit, and then maybe a layer of green and then an orangy-red on top of that and then keep going until he achieved the colour he was looking for. It was a complicated process because he had to maintain his surface texture. It wasn't just ultimate flatness. What it does is give you highlights and shadows and everything in-between. Some parts look darker, some brighter

> and some in the middle. It increases the richness of the colour. So it was very important that he could keep the weave of the canvas visible. The colour would die otherwise (Towe June 10, 2015).

Guacher was able to expand his process with Chromatech's chalky extending medium that. The mattness of the paint meant that imperfections would not show and that incredibly thin layers could be added that could still achieve even coverage (Towe June 10, 2015). This extender contained nepheline syenite, which is a feldspar material and not quite as hard a granite. Towe would make a recipe that was almost like paint and deliver it to Gaucher's studio. The brand name was Mynex 2, which was fairly coarse. While there were finer Minex grades available, Gaucher needed the coarseness of Minex 2 to hold his texture (Towe June 10, 2015) (fig. 5).

Towe would work with Gaucher to find the best matte extenders; he would try different formulations and give them to Gaucher to try. Gaucher would experiment with thinning down the Chromatech paints to the consistency and mattness he needed. Towe would try things like calcium carbonate and granite powders. He describes them as being white or very close to white and transparent, and they would work by bending and scattering light in different ways depending on the surface roughness. Gaucher began using Towe's paints around 1981 or 1982, but it wasn't until the early 1990s that

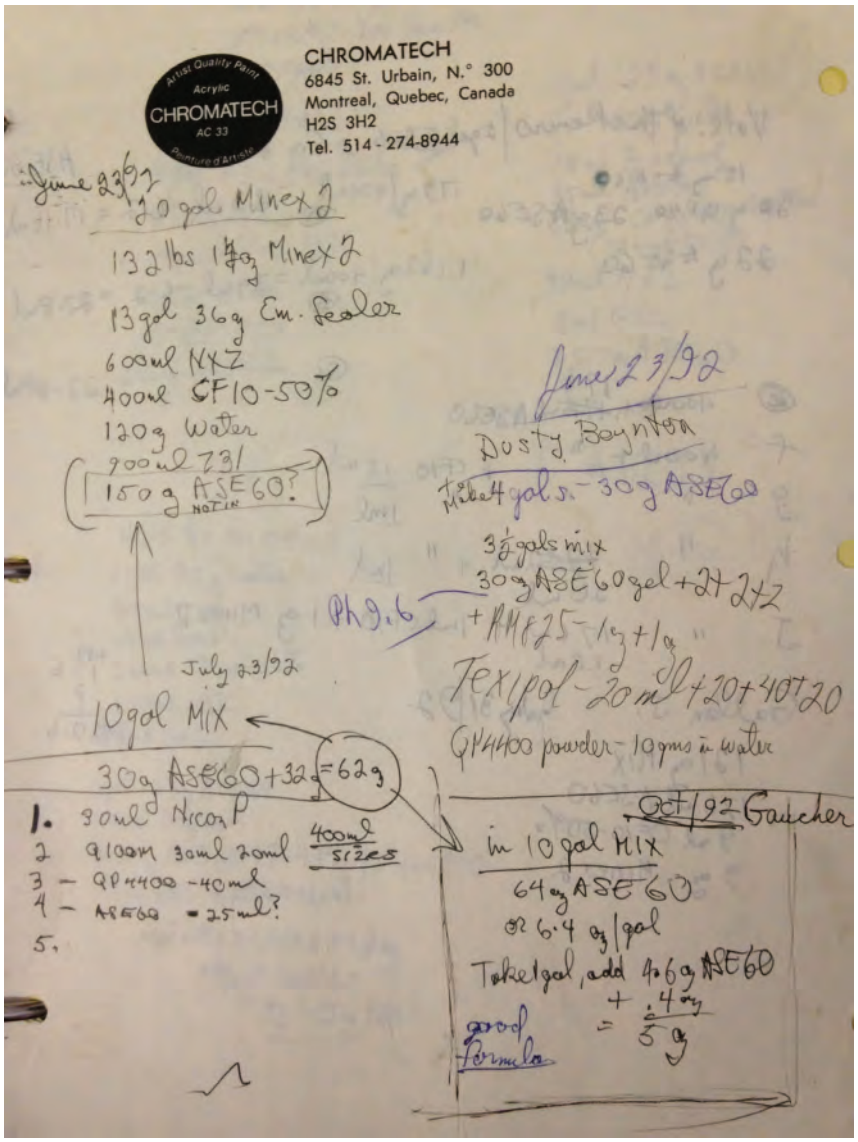

Figure 5. The image shows the different recipes Towe tried before arriving at a "good formula" (bottom right) for Gaucher's matte-extending medium.

he asked Towe for a matte extender. "We had a good working relationship and it was beneficial to both of us," remembers Towe (June 10, 2015).

5. CONSERVATION CONCERNS

With a nod to the former NGC Canadian art curator Denise Leclerc's 1992 travelling exhibition "The Crisis of Abstraction in Canada," a future propositional title could be "The Quietude of the Monochrome in Montreal," for an exhibition that looks at acrylic paint and abstract painting, taking up from where Leclerc left off in her 1992 exhibition. It is a "quietude" because the large-scale acrylic monochrome paintings have remained incredibly stable to date. And while it is not necessary to create crisis where there is none, preemptive archiving is the key to contemporary art stewardship. Kate Helwig and Marie-Chantalle Poisson set precedent with their documentation of the paints in Yves Gacher's studio in 2004. No critical treatment was needed at that point in time, and neither is there now. We do not know how these acrylic paintings will perform 50 years from now; however, knowing their specific ingredients will go a long way toward equipping us with the information we need to prevent and conserve damage. When in 1992 the former head of conservation at the NGC, Marion Barclay, became aware that a number of the artists participating in *Crisis of Abstraction* were using Chromatech acrylic, she had the foresight to order a comprehensive batch from Michael Towe. These paints are in the NGC laboratory and will be tested as part of this research initiative.

Legris Conservation has treated a large number of Molinari, Tousignant, and Gaucher paintings—the majority of which were from the 1960s and coming from private owners, galleries, and art dealers. Most frequently the issues were handling related. Sometimes there is cracking or scuffing along the edges as well scuffing on the image surface. Most often, these issues can be removed mechanically or with light surface cleaning. Sometimes a small amount of consolidation is needed and, infrequently, inpainting. Both Patrick and David Legris expressed that inpainting with the monochromes can be difficult, and they have used more things than is possible to name or generalize in order to match the surface. Marie-Noel Challan-Belval at the Contemporary Art Museum of Montreal, Richard Gagnier at the Musee de Beaux Art in Montreal, Debra Daly-Hartan at the Canadian Conservation Institute, and Susan Walker and Geneviéve Saulnier at the National Gallery of Canada report similarly. The course of treatment for these paintings is primarily preventative. This is why framing initiatives like the HTS frames implemented by Marion Barclay at the NGC in 1992 through the necessity of the travelling Crisis of Abstraction exhibit are paramount (Barclay April 4, 2016). The durable frames cut down on the need for big crates and served to protect the paintings at all times. Barclay's frame design was based off of storage frames she encountered while working at the Tate museum.

6. CONCLUSION

Why autopoiesis? Two arguments have been made here: First, acrylic paint was made for a type of expression that was not previously possible and second, the specific production of these artists was not intention-driven. The artistic practices of Molinari, Tousignant, and Gaucher were threads alongside cultural, industrial, material, and art historical threads that came to be woven and tied together in the form of monochrome painting. For this reason, their artistic intention is no more important than the materials used, the environment of their making, or their continued being. The artists' use of Chromatech paint and their relationship with Towe highlights their immersion within the properties and possibilities of acrylic paint and the potentials of its expression. Here the intentionality of the artist and the intentionality of the paint, if you will, become integrated. This is what autopoiesis emphasizes.

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Bocour Paints and Barnett Newman Paintings: Context and Correlations

ABSTRACT

Barnett Newman, a seminal figure in the Abstract Expressionist movement, was an early adopter of solution acrylic paints, and frequently purchased Bocour Aquatec materials. XRF analysis of his works dating from 1965 to 1970 and comparison with Bocour products reveals that paints on his works most often do not correspond to the pure historical paints available for analysis. However, strong similarities in the XRF elemental signatures of paints used on different works suggest the use of a bespoke paint or specific mixture crafted by or for Newman. These associations allow temporal relationships between paintings to be established.

1. INTRODUCTION

Barnett Newman was one of the iconic artists of the Abstract Expressionist movement in the United States of America. Born in 1905, Newman evinced an early interest in art, and in 1922 enrolled in classes at the Art Students League in New York, a school he continued to attend while studying philosophy at the City College of New York (Temkin 2002). After graduating from college he experimented with several different trades: he worked in his family's clothing manufacturing store, served as a substitute teacher in the New York Public School System (he repeatedly failed the art test required for full employment), contributed to the art scene as a critic and exhibition organizer, and even ran for the position of mayor of New York City; and all the while, he continued to paint. Newman's own philosophical bent, combined with the political upheavals of the time, in particular the atrocities of the Holocaust and World War II, caused him to seek out a new visual language, one that was completely nonrepresentational as no forms or figures could allow a viewer to transcend the realities of the day (Newman 1990).

The pivotal moment came in 1948 when Newman placed a strip of masking tape over a deep red canvas surface and painted the tape a more vivid red with lively brushstrokes (Schiff 2004). Struck by this vertical line bisecting a simple field of color Newman contemplated the painting, internalizing the relationship between color, form, and canvas for nine months. The vertical strip, or "zip" as it became known, served as both a mimic of the upright human form and as a physical point of reference: something for the viewer to lock onto as they approached, stood by, and moved past the canvas (Mancusi-Ungaro 2004). This converted Newman's paintings from a two-dimensional surface to a four-dimensional experience.

Because the colors of the field and zip were critical, as was the paint surface, Newman was very careful about his materials (Mancusi-Ungaro 2004). He reportedly went over all of his canvases by hand, removing any nubs that would catch the viewer's eyes and interfere with the experience. He then stretched (and for oil paintings, sized) his canvas, with larger works requiring the help of a studio assistant. He reportedly refused to discard the use of artists' paints as so many other artists active at the time were doing. He had no issues with the associations of these materials with classic representational art, but rather valued the tried and true stability of artists' paint to ensure his works maintained their color and pristine condition. The color and spatial relationship between the zip and color field were also critical, and Newman would revise both color and composition until satisfied with the composition (Epley and Rogge 2015).

Despite his concern and care about materials, Newman was not averse to the use of new materials and was actively interested in new developments. The field of paint manufacturing blossomed in the 20th century with the introduction of new paints and colors. The use of synthetic polymeric binding media began with the introduction of Bocour Magna Plastic Paint in the 1940s, a type of solvent acrylic that used poly(n-butyl methacrylate) (p-(nBMA)) as a binder (Lodge 1988, Learner 2000). Solution, or water-borne acrylics, which use a Rohn & Haas Rhoplex AC-33 polymer (a mixture of methyl methacrylate,

ethylacrylate and ethyl methacrylate polymers (p(EA:MMA)) were introduced in 1954 by Permanent Pigments under the name Liquitex and followed by the Bocour Aquatec line in 1963 (Learner 2000, Marontate 1996). Newman adopted both solvent and solution acrylics very early on. He utilized Magna in his 1949 painting *Abraham*, well before the 1953 date when that paint was widely available (Schiff, Mancusi-Ungaro, and Colsman-Freyberger 2004). The *Ninth Station* of the *Stations of the Cross: Lema Sebactani* series and *White Fire III,* both painted in 1964, contain solution acrylics. This willingness on Newman's part to use new and relatively untested materials may have come from the personal relationships he had with Leonard Bocour and his nephew Sam Golden, a partner in the firm and the individual most directly responsible for the manufacture of Bocour paints (Marontate 1996).

Leonard Bocour, who had also studied art at the Art Students League, was a friend of many artists, and many of his early paint sales were to artists that he knew through the school or local community (Bocour 1978). The Bocour company workshop became a social hub, with artists such as Willem De Kooning, Morris Louis, Mark Rothko, Jack Levine, Elias Friedensohn, Ahron Ben-Shmuel, and Mara McAffee and comedian Zero Mostel (Marontate 1996; Golden 2012) visiting and socializing. Jack Levine recounted that he often slept off benders on the studio couch and participated in Saturday crap games (Marontate 1996). Although Sam Golden was less involved in the social and marketing aspects of the Bocour Company, his skill with paint development led to professional interactions with artists such as Morris Louis, Philip Guston, Helen Frankenthaler, and Barnett Newman who requested custom paints (Upright 1995; Marontate 1996). According to his son, Mark Golden, "Sam truly delighted in these relationships and loved the requests he got from artists to make them something new" (Golden 2012), even though the artists could be demanding and critical. Guston disliked the thicker paint the Bocour Company made for him (Marontate 1996) while Newman rejected certain batches as not containing the pigments advertised (Mancusi-Ungaro 2004) and would ask Golden to run an order down to the subway and pass it to him through the gate, so that Newman could avoid paying a return fare (Golden 2015).

Personal histories, receipts for the purchase of Bocour paints held in the Barnett Newman Foundation Archives, and the discovery of Bocour paints in Newman's studio after his death confirm that Newman purchased Bocour paints. Analysis of early works such as the *Stations of the Cross: Lema Sebactani* series, *The Name II* (1950), *Cathedra* (1951), and *Achilles* (1952) have confirmed the presence of p(n-BMA) as the binder, indicating the presence of Magna as no other paint of the time period used that binding polymer (Schiff, Mancusi-Ungaro, and Colsman-Freyberger 2004). However, the later Newman works dating from 1965 to 1970, which primarily utilize solution acrylics, have not been as extensively analyzed, and as multiple brands of solution acrylic paints were available by that time, precise identification of a paint on a given painting as a Bocour Aquatec has not thus far been possible. An exhibition held at the Menil Collection in spring of 2015, *Barnett Newman: The Late Work*, gathered together a collection of works from the Menil's holdings such as *Now II* (1967) and three unfinished paintings found in Newman's studio at the time of his death, as well as works from other institutions including *White and Hot* (1967), *White Fire IV* (1968), *The Way II* (1969), *Be I* (*Second Version*) (1970), and *Untitled I* (1970). The exhibition also presented ephemera such as tweezers, a straw hat, and paint rollers as well as samples of Aquatec acrylics and unlabeled jars of acrylic paint found in Newman's studio at the time of his death from the Harvard Art Museums Center for the Technical Study of Modern Art (CTSMA) (Table 1). Additional unlabeled jars of Newman's acrylic paints were donated to the Menil by Robert Murray. Thanks to the cooperation of lending institutions, all works were analyzed by pXRF. Paintings held by the Menil and *The Way II* (1969) and *White and Hot* (1967), from Fondation Beyeler and The St. Louis Art Museum, respectively, were also sampled and analyzed by FTIR and Raman spectroscopy to further identify pigments and binding media. The results were interpreted in the context of previous analyses performed on historic Bocour paints held in the National Gallery of Art Materials Research and Study Center and the Menil Collection (Rogge and Epley 2016). Surprisingly, analysis shows that, in the vast majority of cases, the paints on the paintings do *not* correspond to the historical Bocour paints available for analysis. However, there are strong similarities in the elemental compositions of paints used on different paintings. Such correspondences could arise from different batches of either Bocour or artist-derived custom-made paints. If Newman had been mixing his own paints, he must have either made large enough batches to use on multiple works, or followed recipes consistently enough to duplicate the elemental ratios so as to be indistinguishable by the technique used here.

2. MATERIALS AND METHODS

2.1 Bocour Paint Samples

The National Gallery of Art Materials Research and Study Center (NGA MSC; http://www.nga.gov/content/ngaweb/conservation/materials-study-center.html) kindly provided access to their samples of historic Bocour paints. An additional five samples of Aquatec paints were purchased from online vendors. Robert Murray donated to the Menil a collection of Bocour Hand Ground Oils, Bellini, and Artists Oil Color paints that were in Newman's studio at the time of his death.

2.2 Paintings
Paintings analyzed in this study are *Now II* (1967), acrylic on canvas, 335.9 × 127.3 cm The Menil Collection, formerly in the collection of Christophe de Menil; *Voice of Fire* (1967), Magna on canvas, 543.6 × 243.8 cm, the National Gallery of Canada, Ottawa; *White and Hot* (1967), oil on canvas, 213.4 × 182.9 cm, Saint Louis Art Museum, gift of Mr. and Mrs. Joseph Pulitzer Jr.; *White Fire IV* (1968), acrylic and oil on canvas, 335.6 × 127.3 cm, Kunstmuseum Basel; *Shimmer Bright* (1968), oil on canvas, 182.9 × 214 cm, the Metropolitan Museum of Art, gift of Annalee Newman, 1991; *Yellow Edge* (c. 1968), acrylic on canvas, 238.4 × 193.2 cm, the National Gallery of Canada, Ottawa, gift of Annalee Newman, 1990; *The Way II* (1969), acrylic on canvas, 198.5 × 152.5 cm, Fondation Beyeler, Riehen/Basel, Switzerland, Beyeler Collection; *Be I (Second Version*), acrylic on canvas, 283.2 × 213.4 cm, Detroit Institute of Arts/The Bridgeman Art Library; *Midnight Blue* (1970), acrylic and oil on canvas, 193 × 238.8 cm, Museum Ludwig, Cologne, Germany; *Untitled I* (1970), acrylic on canvas, 196.9 × 152.4 cm, San Francisco Museum of Modern Art, fractional gift and bequest of Mrs. Paul L. Wattis; *Unfinished Painting* [*Red & White 1970*] (1970), acrylic on canvas, 243.8 × 548.6 cm, the Menil Collection, gift of Annalee Newman; *Unfinished Painting* [*Blue & Brown 1970*] (1970), acrylic on canvas, 213.4 × 193 cm, the Menil Collection, gift of Annalee Newman; and *Unfinished Painting* [*The Sail*] (1970), acrylic on canvas, 243.5 × 300.4 cm, the Menil Collection, gift of Annalee Newman.

2.3 Ephemera
Ephemera from the CTSMA collection that were analyzed include a woven straw hat splashed with paint and worn by Newman (TL2015.2.2); two paint rollers with remnants of red paint (TL2015.2.3 and TL2015.2.5; a pair of nickel plated tweezers with red paint (TL2015.2.10); a tri-colored canvas fragment with white, dark red and bright red paint (TL2015.2.19); and a bi-colored canvas fragment with red and white paint (TL2015.2.20). The Menil Collection ephemera holdings consist of a blue and white painted canvas fragment.

2.4 X-Ray Fluorescence Spectroscopy
X-ray fluorescence spectra were collected using a Bruker Tracer III-SD handheld energy dispersive x-ray spectrometer equipped with a Peltier cooled XFlash silicon drift detector (SDD) with a resolution of 145 eV. The excitation source was a Rhodium (Rh) target x-ray tube, operated at 40 kV and 10 μA current and spectra were collected over 120 seconds (live time). Spectral interpretation was performed using the Bruker Artax Spectra 7.4.0.0 Software.

2.5 Attenuated Total Reflection FTIR Microscopy
ATR spectra were collected using either a Lumos FTIR microscope equipped with a motorized germanium ATR crystal with a 100 μm tip (Bruker) or a Nicolet Nexus 670 FTIR spectrometer (Thermo Scientific) equipped with a Smart iTx diamond ATR accessory and DGTS detector. Samples analyzed using the Lumos FTIR microscope were placed on glass slides and analyzed using the built-in 8x objective and a medium ATR crystal pressure. An approximately 150 μm x 150 μm square microscope aperture was used to isolate the sample area for analysis. The spectra are an average of 128 scans at 4 cm^{-1} spectral resolution. An ATR correction was automatically applied by the Opus 7.0 instrument control and data collection software (Bruker). For the Nexus 670 FTIR, samples were pressed against the diamond ATR crystal. The spectra are an average of 32 scans at 4 cm^{-1} spectral resolution. An ATR correction was automatically applied by the Omnic instrument control and data collection software (Thermo Scientific). Sample identification was aided by searching a spectral library of common conservation and artists' materials (Infrared and Raman Users Group, http://www.irug.org) using the Omnic software.

2.6 Dispersive Raman Microspectroscopy
Dispersive Raman spectra were collected on an InVia Raman microscope (Renishaw) using a 785 nm excitation laser operating at a power of 114 μW, 635 μW, 1.27 mW, 5.43 mW or 9.71 mW at the sample as measured using a PM100D laser power meter (Thorlabs) equipped with a S120C photodiode power sensor. A 5× objective was used to focus the excitation beam on the sample supported on a glass microscope slide. The resulting Raman spectra are the average of 1 to 15 scans of 10 sec duration. Spectral resolution was 3-5 cm^{-1} across the spectral range analyzed. Sample identification was achieved by comparison of the unknown spectrum to spectra of reference materials, the KIK/IRPA Raman reference library (Fremout and Saverwyns 2012) and to those published in the literature.

3. RESULTS

Table 1 summarizes the findings on the paintings and ephemera analyzed in this study. While XRF is a commonly used non-destructive, non-contact form of elemental analysis there are limitations and caveats to the information that can be obtained. Light elements below aluminum in atomic weight are very difficult to detect, thus carbonaceous pigments and binders cannot be detected other than as a contribution to bremsstrahlung radiation (McGlinchey 2012). Some elements have overlapping peaks (for example the Ti K_α and Ba L_α lines) and therefore care must be taken in determining whether one or both of the overlapping elements is present. The x-ray beam penetrates below the surface, and the depth from which the detected signals arise depends upon the energies of the exciting x-ray source and the emitted x-ray fluorescence, and the composition of the paint layer(s) (Mantler and Schreiner 2000). This x-ray

penetration often allows the surface and underlying ground and paint layers to be co-analyzed and information regarding the relative depth of a given elemental signal extracted by comparison of different fluorescence peaks arising from a given element. Lower energy peaks are attenuated more by the matrix and overlaying paint layers than higher energy lines, so comparison of peak ratios, such as K_α/L_α or K_α/K_β, can help localize an element within the stratigraphy of a painting (Mantler and Schreiner 2000, McGlinchey 2012). The effects of penetration, matrix absorptivity and the energy dependence of the observed peak intensities complicates the use of XRF as a quantitative technique (Glinsman 2005). However, the qualitative information obtained is often quite useful in the examination of paintings. While XRF is unable to conclusively determine the identity of the pigments and fillers, educated hypotheses are often possible, particularly given the relatively limited range of many contemporaneous acrylic paint lines (Bocour 1964). Furthermore, the peak intensities of different elements in a given paint are related to concentrations, so each paint can be said to have an elemental "signature" consisting of elements present and their relative intensities. Thus, comparison of the spectra of two different paint samples analyzed under identical conditions can establish whether they have similar signatures. Comparisons of the elemental signatures of paint on the late Newman works with those previously obtained from historic Bocour paints (Rogge and Epley 2016) can then establish whether unmodified Bocour paints are present on the works.

3.1 White Paint

Nine paintings, three canvas fragments (two from the CTSMA and one from the Menil), and the straw hat contain white acrylic paint whereas two paintings, *Shimmer Bright* and *White and Hot* have white oil paints. Paint outs of historic Aquatec *Titanium White*[1] and Bellini *Titanium White, Flake White,* and *Titanium Zinc White* were available for comparison.

The Aquatec paint *Titanium White* shows, by XRF, only titanium with very little signal arising from other elements, including calcium. Two paintings, *Now II* (1967) and *White Fire IV* (1968) have white paints that are similarly simple in elemental composition (figs. 1 and 2). The white paint from the straw hat also appears to be analogous, so these objects may have been painted using pure, unmodified Aquatec *Titanium White*. The white paint on *Be I* (1970) has slightly elevated calcium levels, but the calcium K_α peak is attenuated with respect to the K_β peak suggesting that the signal may derive from a subsurface layer rather than the surface white paint. Therefore this paint may also be an unmodified tube paint. A second group of paintings, including *Yellow Edge* (c. 1968), *The Way II* (1969), *Midnight Blue* (1970), *Unfinished Painting* [*The Sail*] (1970), *Unfinished Painting* [*Red & White 1970*] (1970) have significantly more calcium, and the Ca K_α/Ti K_α ratios are all similar, clustering around 0.1. Cross section samples taken from *Now II* and *The Way II* confirm the presence of a single white layer so the presence of calcium is unlikely to derive from a calcium containing ground, but rather from calcium containing materials (likely primarily calcium carbonate given the low sulfur content) added to the titanium white paint. The Ca K_α/Ti K_α ratios of *Untitled I* (1970) and the blue and white canvas fragment are higher, at about 0.25, and likely represent a different mixture. The two red and white canvas fragments from the CTSMA have the highest amount of Ca, and likely the same mixture of white paint. Receipts from the Barnett Newman Foundation Archives suggest that Newman did commission specific paints from Bocour (BNFA), so these different white paints could represent different commissions, but Newman himself could have added calcium carbonate as an extender to the titanium white paints in order to reduce costs, to create a specific tone or texture, or to obtain desired handling properties. Robert Murray remembers Newman adding powdered materials, perhaps pigments or extenders, to paints, so perhaps these four groups represent different Newman created mixtures (Murray 2015).

The presence of distinct groups of white paints suggests temporal associations between different paintings. *Now II* (1967) and *White Fire IV* (1968) are the two earliest paintings and fall into their own distinct group. The largest group of white paints includes paintings dated c. 1968 (*Yellow Edge*), 1969 (*The Way II*), and 1970 (*Midnight Blue, Unfinished Painting* [*Red & White 1970*], and *Unfinished Painting* [*The Sail*]); the three from 1970 were all found in Newman's studio at the time of his death. The close relationship between the paints on these paintings suggests that the date of c. 1968 for *Yellow Edge* may be slightly early, and that the painting, at least in terms of the white paint's elemental signature, more closely fits into later works. *Untitled I*, also found in Newman's studio at the time of his death, has a different paint ratio that matched a fragment of another blue and white painting destroyed by Newman (the canvas fragment held by the Menil). The distinct paint composition for these two objects could indicate the creation of a new batch of white paint after the batch used to paint the five paintings in the large group was exhausted. The two red and white canvas fragments from the CTMSA have yet another calcium to titanium ratio and likely were made using a different batch of white paint. These fragments are undated and, unfortunately, the distinct Ca K_α/Ti K_α ratio of their white paints does not allow them to be tied to other works.

The white oil paints on *Shimmer Bright* (1968) and *White and Hot* (1968) are similar: both contain high levels of zinc, lead, barium, and titanium suggesting the presence of zinc white, lead white, titanium white, and barium sulfate, although the

Table 1. Pigments and binders present on late Barnett Newman paintings and ephemera

Title	Year	Color[a]	Elements Detected by XRF[b]		Pigments Suggested by XRF	Binding Media Identified by FTIR	Pigments and Fillers Identified by FTIR and Raman	Institution
			Major	Minor				
Now II	1967	White	Ti	Al, Si, S, K, Ca, Fe	Titanium white	p(EA:MMA)	$CaCO_3$, kaolinite, rutile	The Menil Collection
		Black (over white)	Fe	Al, Si, S, K, Ca, Ti, Cr, Mn, Cu, Zn	Fe_3O_4	p(EA:MMA)		
White and Hot	1967	White	S, Ca, Ba, Ti, Zn, Pb	Si, K, Mn, Fe, Sr	Titanium white, zinc white, lead white	drying oil	$CaSO_4$, $CaCO_3$, rutile	St. Louis Art Museum
		Red (over white)	S, Cd, Ca, Ba, Zn, Pb, Se	Si, K, Fe, Sr	Cadmium sulfoselenide	drying oil	$BaSO_4$	
Voice of Fire[c]	1967	Orange	S, Cd, Ba, Hg, Se	Si, Fe, Sr	Cadmium mercury sulfoselenide			National Gallery of Canada
		Blue (over white)	S, Ti, Co, Cu	Al, Si, K, Ca, Fe, Zn	Cobalt blue, ultramarine blue, phthalocyanine blue, titanium white			
Yellow Edge[c]	ca. 1968	Black (over white)	Ca, Ti, Fe	Al, Si, S, K, Mn, Cu, Zn	Titanium white, Fe_3O_4, $CaCO_3$ and/or $CaSO_4$			National Gallery of Canada
		Yellow 1[d]	Cl, Ba	Si, Cd, Ca, Ti, Fe, Zn, Sr	Hansa yellow, $BaSO_4$, cadmium sulfide			
		Yellow 2[d]	S, Cd, Ba	Si, Cl K, Ca, Fe, Zn, Sr	Cadmium sulfide, $BaSO_4$, Hansa yellow			
Shimmer Bright	1968	White	S, Ca, Ba, Zn, Pb	Si, Ti, Fe, Sr	Lead white, zinc white, $BaSO_4$, $CaCO_3$ and/or $CaSO_4$, titanium white			The Metropolitan Museum of Art
		Blue (over white)	S, Ca, Ba, Zn, Pb	Si, Ti, Fe, Cu, Sr	Lead white, zinc white, $BaSO_4$, $CaCO_3$ and/or $CaSO_4$, titanium white, phthalocyanine blue			

Title	Year	Color[a]	Elements Detected by XRF[b] Major	Elements Detected by XRF[b] Minor	Pigments Suggested by XRF	Binding Media Identified by FTIR	Pigments and Fillers Identified by FTIR and Raman	Institution
The Way II	1969	White (ground)	Ca, Ti	Al, Si, S, K, Fe	Titanium white, $CaCO_3$ and/or $CaSO_4$	p(EA:MMA)	$CaCO_3$, kaolinite, rutile	Fondation Beyeler
		Red (over white)	Ba, Ti, Se	Si, S, Cd, K, Ca	Barium sulfate, cadmium sulfoselenide	p(EA:MMA)		
		Black (over white)	Ca, Ti, Fe	Al, Si, K, Cr, Mn, Cu	Fe_3O_4, $CaCO_3$ and/or $CaSO_4$	p(EA:MMA)	Fe_3O_4	
Untitled I	1970	White	Ca, Ti	Al, Si, S, K, Fe, Cu, Zn, Sr	Titanium white and $CaCO_3$			San Francisco Museum of Modern Art
		Blue 1[e]	Sn, Ti, Cr, Co	Al, Si, S, K, Fe, Cu, Zn	Titanium white, cobalt chromate cerulean blue, cobalt stannate cerulean blue			
		Blue 2 (over white and blue 1)	Ca, Ti, Co, Cu	Al, Si, S, Sn, Cr, Fe, Cu, Zn, Se	Titanium white, cobalt chromate cerulean blue, cobalt stannate cerulean blue			
Be I (*Second Version*)	1970	White (over red)	Ca, Ti, Se	Al, Si, S, Cd, K, Fe	Titanium white, $CaCO_3$ and/or $CaSO_4$, cadmium sulfoselenide			Detroit Institute of Arts
		Red	Cd, Se	Si, S, Ti, Fe, Cu, Zn	Cadmium sulfoselenide			
Midnight Blue	1970	White	Ca, Ti	Al, Si, S, K, Fe, Cu, Zn, Sr	titanium white, $CaCO_3$ and/or $CaSO_4$, cobalt chromate cerulean blue,			Museum Ludwig
		Dark blue (over white)	Ca, Ti, Cu	Al, Si, S, Cl, K, Cr, Fe, Co, Zn, Sr	Copper phthalocyanine, titanium white, $CaCO_3$ and/or $CaSO_4$			
		Light blue zips (over white)	Pb	Ca, Ti, Fe, Cu, Zn	Lead white			
Unfinished Painting (*The Sail*)	1970	White	Ca, Ti	Al, Si, S, K, Fe, Zn, Br	Titanium white	p(EA:MMA)	$CaCO_3$, kaolinite, rutile	The Menil Collection

Title	Year	Color[a]	Elements Detected by XRF[b] Major	Elements Detected by XRF[b] Minor	Pigments Suggested by XRF	Binding Media Identified by FTIR	Pigments and Fillers Identified by FTIR and Raman	Institution
Unfinished Painting [*Red & White 1970*]	1970	White	Ca, Ti	Al, Si, S, K, Fe, Zn, Br, Sr	Titanium white, $CaCO_3$ and/or $CaSO_4$	p(EA:MMA)	$CaCO_3$, kaolinite, rutile	The Menil Collection
		Red (over white)	S, Cd, Se	Si, Ca, Ti, Fe, Zn	Cadmium sulfoselenide	p(EA:MMA)		
Unfinished Painting [*Blue & Brown 1970*]	1970	Blue	Ca, Ti, Cu	Al, Si, S, K, Cr, Mn, Fe, Zn, Sr, Br	Phthalocyanine blue, titanium white, $CaCO_3$ and/or $CaSO_4$	p(EA:MMA)	$CaCO_3$, kaolinite, phthalocyanine blue	The Menil Collection
		Red	S, Cd, Se	Si, Ti, Fe	Cadmium sulfoselenide	p(EA:MMA)		
		Brown (over red)	S, Cd, Mn, Fe, Se	Si, Ca, Ti, Ni, Cu	Umber, cadmium sulfoselenide	p(EA:MMA)		
Woven Brimmed Hat		Black with red	Fe	Si, S, K, Cd, Ca, Ba, Cr, Mn, Cu, Zn, Pb, Se, Br	Fe_3O_4, cadmium sulfoselenide, $BaSO_4$			Harvard Art Museums
		White	K[f], Ti, Ba	Al, Si, P, Ba, Cu, Zn, Pb, Br	Titanium white			
		Yellow	K[f]	Si, P, Cd, Ca, Fe, Cu, Zn, Br	Cadmium sulfide			
		Red with blue	S, Cd, Ba	Al, Si, K, Ca, Cr, Fe, Co, Cu, Zn, Se, Pb, Sr	Cadmium sulfoselenide, cobalt chromate cerulean blue			
		Blue	K[f], Ba, Co, Pb	Al, Si, Ca, Fe, Cu, Zn,	Cobalt blue, barium sulfate			
		Dark blue with red	K[f]	Al, Si, P, S, Cd, Ca, Ba, Cr, Fe, Co, Cu, Zn, Pb, Se, Br	Cobalt blue, cobalt chromate cerulean blue, $BaSO_4$, cadmium sulfoselenide			
Tweezers (TL2015.2.10)		Red (on nickel plated steel)	Cd, Fe[f], Ni[f], Se	Si, S, Ca, Ti, Mn	Cadmium sulfoselenide			Harvard Art Museums

Title	Year	Color[a]	Elements Detected by XRF[b] Major	Elements Detected by XRF[b] Minor	Pigments Suggested by XRF	Binding Media Identified by FTIR	Pigments and Fillers Identified by FTIR and Raman	Institution
Canvas Fragment 1 (TL2015.2.19)		White (partially under red)	Ca, Cd, Ti, Se	Al, Si, S, K, Mn, Fe, Cu, Zn, Sr	Titanium white, $CaCO_3$ and/or $CaSO_4$, cadmium sufoselenide			Harvard Art Museums
		Darker red (over white)	Cd, Ti, Se	Si, Ca, Fe, Cu, Zn, Sr	cadmium sulfoselenide, titanium white, $CaCO_3$ and/or $CaSO_4$			
		Lighter red (over white)	Cd, Ti, Se	Si, K, Ca, Fe, Cu, Zn, Sr	Cadmium sulfoselenide, titanium white, $CaCO_3$ and/or $CaSO_4$			
Canvas Fragment 2 (TL2015.2.20)		White	Ca, Ti	Al, Si, S, K, Mn, Fe, Cu, Zn, Sr	Titanium white, $CaCO_3$ and/or $CaSO_4$			Harvard Art Museums
		Red (over white)	Cd, Se	Si, S, Ca, Ti, Fe, Cu, Zn, Sr	Cadmium sulfoselenide, titanium white			
Canvas Fragment 3		White			Titanium white, $CaCO_3$ and/or $CaSO_4$			The Menil Collection
Canvas Fragment 3		Blue (over white)	Ti, Cr, Co	Al, Si, S, Sn, Ca, Fe, Cu, Zn	Cobalt chromate cerulean blue, Cobalt stannate cerulean blue, phthalocyanine blue, titanium white			The Menil Collection
Paint Roller 1 (TL2015.2.3)		Red (on fibers)	Cd, Se, Fe[f]	S, K, Ca, Ti, Cu, Zn	Cadmium sulfoselenide			Harvard Art Museums
Paint Roller 2 (TL2015.2.5)		Red	Cl[f], Se	Al, Si, S, Cd, Fe, Cu, Zn	Cadmium sulfoselenide			Harvard Art Museums
Unlabeled jar of blue paint (1)		Blue	S, Fe	Al, Si, K, Ca, Ba, Ti, Cr, Cu, Zn, Rb, Sr	Ultramarine	p(EA:MMA)	Ultramarine	Harvard Art Museums
Unlabeled jar of blue paint (2)		Blue	Cr, Co	Al, Si, S, Ca, Ti, Fe, Cu, Zn	Cobalt chromate cerulean blue	p(EA:MMA)	Metal oxide	Harvard Art Museums
Unlabeled jar of blue paint (3)		Blue	Co, Zn	Al, Si, S, Ca, Ti, Cr, Fe	Cobalt zinc blue	p(EA:MMA)		Harvard Art Museums
Unlabeled jar of red paint (4)		Red	Cd, Se	Si, S, Ba, Fe, Cu, Zn	Cadmium sulfoselenide	p(EA:MMA), PEG		Harvard Art Museums
Unlabeled jar of red paint (5)		Red	S, Cd, Se	Si, Ba, Fe, Cu, Zn	Cadmium sulfoselenide	p(EA:MMA)		Harvard Art Museums

Title	Year	Color[a]	Elements Detected by XRF[b] Major	Minor	Pigments Suggested by XRF	Binding Media Identified by FTIR	Pigments and Fillers Identified by FTIR and Raman	Institution
Unlabeled jar of red paint (6)		Red	S, Cd, Se	Si, Ba, Fe, Cu, Zn	Cadmium sulfoselenide	p(EA:MMA)		Harvard Art Museums
Liquitex Cadmium Red Light (7)		Red	S, Cd, Ca, Ba, Se	Fe, Cu, Zn, Sr	Cadmium sulfoselenide, $BaSO_4$, $CaCO_3$ and/or $CaSO_4$	p(EA:MMA)	$BaSO_4$, $CaCO_3$	Harvard Art Museums
Liquitex Cadmium Yellow Light (8)		Yellow	S, Cd, Ba, Zn, Sr	Fe, Hg	Zinc cadmium sulfide, $BaSO_4$	p(EA:MMA)	$BaSO_4$	Harvard Art Museums
Liquitex Cadmium Yellow Medium (9)		Yellow	S, Cd, Ba, Zn, Sr	Fe, Se, Hg	Zinc cadmium sulfide, cadmium sulfoselenide, $BaSO_4$	p(EA:MMA)	$BaSO_4$	Harvard Art Museums
Unlabeled jar of red paint (RM. BN.91)		Red	S, Cd, Se	Si, Ba, Fe, Cu, Zn	Cadmium sulfoselenide	p(EA:MMA)	Silicates	Menil
Unlabeled jar of red paint (RM. BN.92)		Red	S, Cd, Se	Si, Ba, Fe, Cu, Zn	Cadmium sulfoselenide	p(EA:MMA)		Menil
Unlabeled jar of red paint (RM. BN.93)		Red	S, Cd, Se	Si, Ba, Fe, Cu, Zn	Cadmium sulfoselenide	p(EA:MMA)	Silicates	Menil
Unlabeled jar of blue paint (RM. BN.89)		Blue	Cr, Co	Al, Si, S, Ca, Ba, Ti, Fe, Cu, Zn	Cobalt chromate cerulean blue	p(EA:MMA)	Metal oxides	Menil
Unlabeled jar of blue paint (RM. BN.90)		Blue	S, Fe	Al, Si, K, Ca, Ba, Ti, Cr, Cu, Zn, Rb, Sr	Ultramarine	p(EA:MMA)	Ultramarine	Menil

[a] As XRF detects elements present in surface and subsurface layers, the presence of underlying paint layers are in noted in parentheses.

[b] Elements deemed major had peak heights higher than the rhodium lines due to Rayleigh scattering of the primary x-rays. Those deemed minor had peak heights lower than the Rh signal.

[c] XRF data for *Yellow Edge* and *Voice of Fire* were kindly collected by Susan Walker, conservator of Paintings at the National Gallery of Canada, using a Bruker Tracer III-SD handheld energy dispersive x-ray spectrometer equipped with a Peltier cooled XFlash silicon drift detector (SDD) with a resolution of 145 eV. The excitation source was a Rhodium (Rh) target x-ray tube, operated at 40 kV and 11 μA current and spectra were collected over 120 seconds (live time). As judged by the Compton scattering peaks of Rh, the differences in current (10 vs 11 μA) had minimal impact on the spectra.

[d] Examination of the turnover edge revealed two distinct yellows.

[e] Examination of the bottom turnover edge revealed two distinct blues, a lighter blue (blue 1) underlying a darker blue (blue 2).

[f] This element is present in high amounts in the support; the signal likely arises from the support rather than a pigment.

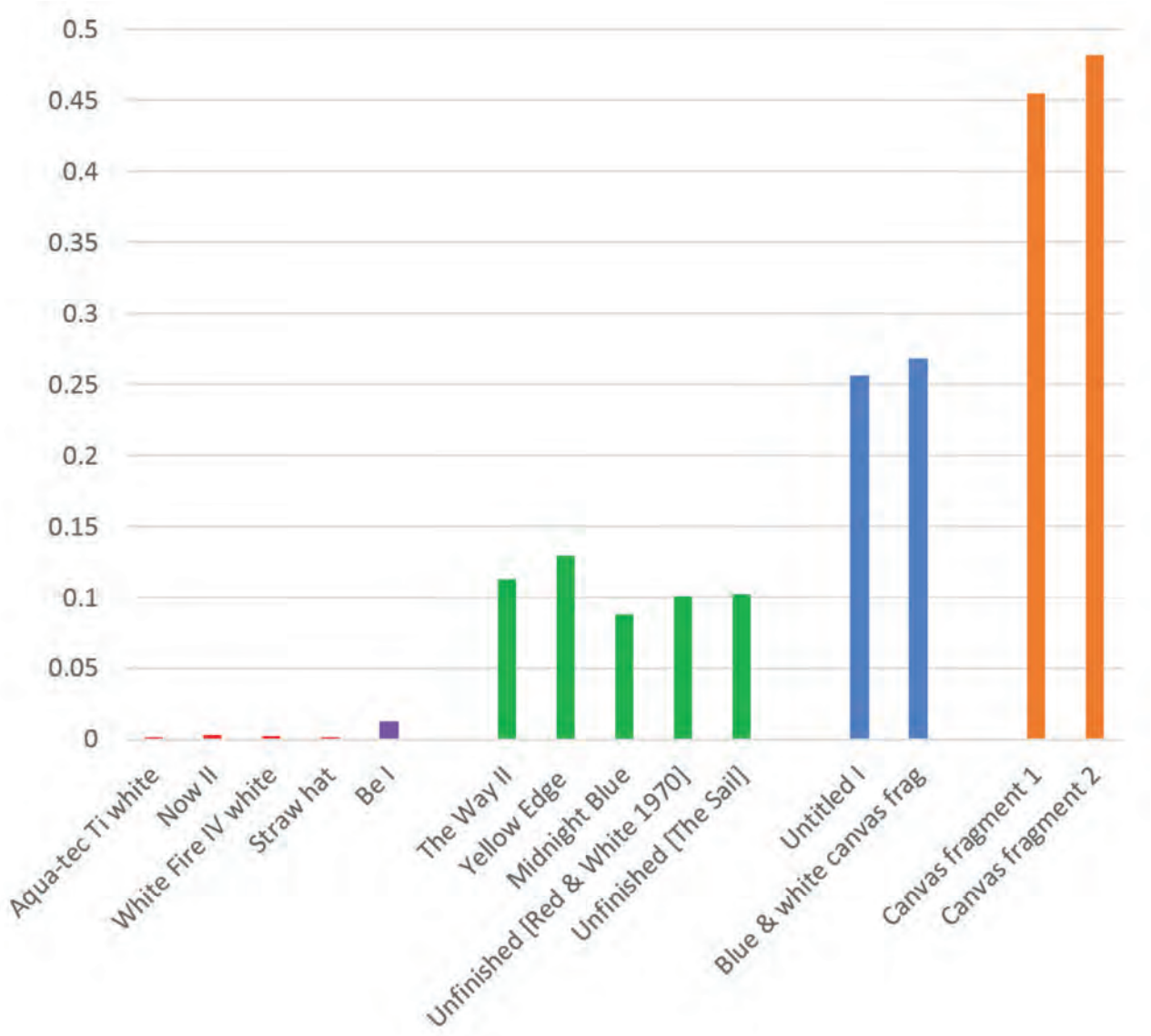

Figure 1. Ca K_α/Ti K_α ratios of white acrylic paints from an historic Aquatec paint sample, paintings, and ephemera. Readily distinguishable ratios are represented with distinct colors.

presence of lithopone, a mixture of barium sulfate and zinc sulfide, cannot be excluded. The two paints are not identical, as *Shimmer Bright* has higher levels of barium and lower levels of calcium and zinc. The spectra of the paints do not correspond to any of the Bocour Bellini white paints held in the National Gallery Materials Study Collection, a collection that includes samples of *Titanium White*, *Titanium-Zinc White*, and *Flake White* paints. The Bellini *Flake White* appears to be a mixture of lead white, zinc white, and barium sulfate (and/or lithopone). The *Titanium White* and *Titanium-Zinc White* Bellini paints are very similar and contain mixtures of titanium white and zinc white along with small amounts of barium sulfate. None of the Bellini paints contains significant levels of calcium. Spectral addition of the Bellini *Flake White* and Bellini *Titanium White* (or *Titanium-Zinc White*) spectra can generate an addition spectrum with similar ratios of zinc, barium, titanium, and lead to those seen in the paintings. However, additional calcium sources would have to be present to reproduce fully the experimental spectra. Such signals could come from a ground present underneath the paint layers; such a structure would be typical for Newman's oil paintings, and is suggested by visual inspection using UV light, but this has not been confirmed by direct sampling or cross sections.

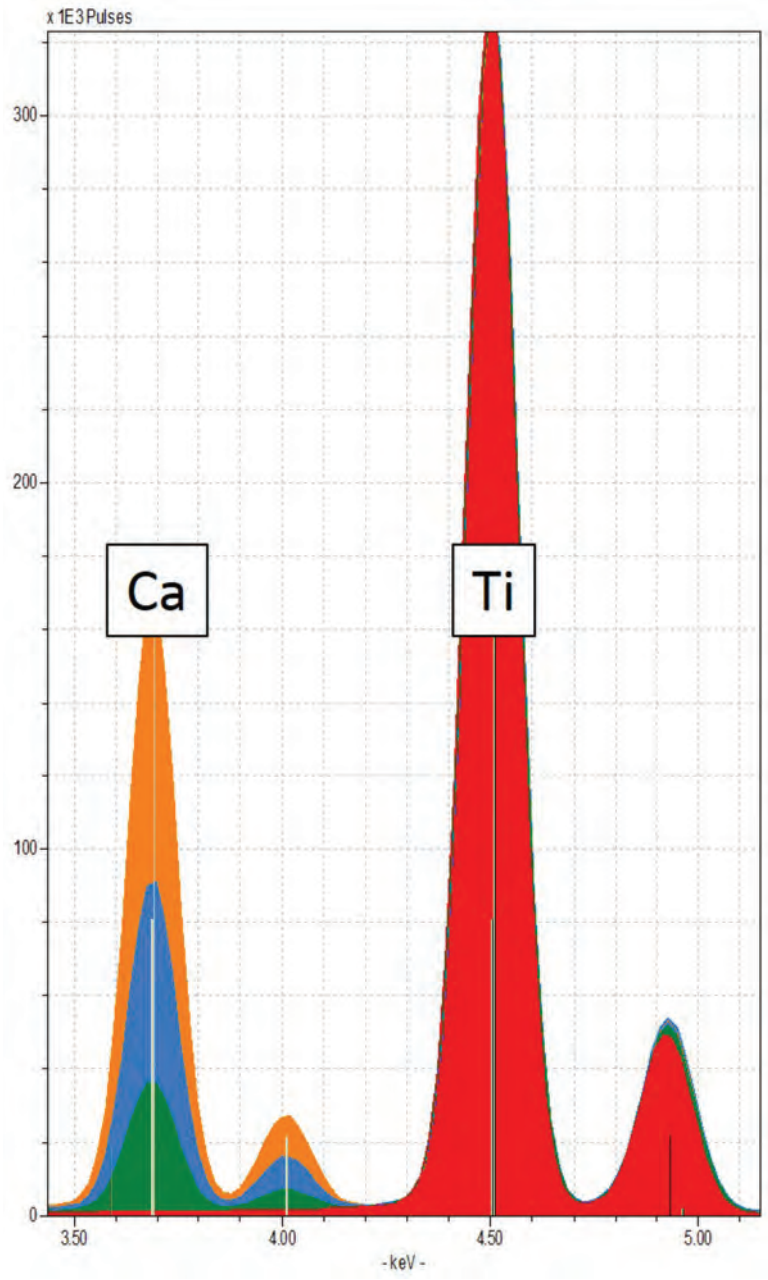

Figure 2. XRF spectra of white paints with distinct Ca K_α/Ti K_α ratios: Red–Aquatec *Titanium White*; Green–*Unfinished Painting* [*Red & White 1970*] (1970); *Untitled I* (1970) (blue); canvas fragment 2 from the CTSMA collection (orange).

3.2 Black Paint

Two paintings, *Now II* (1967) and *The Way II* (1969), and the woven straw hat from CTSMA have black paint, and all three paints appear to utilize magnetite, Fe_3O_4, as the primary pigment: they contain high levels of iron and no detectable phosphorus, which rules out bone/ivory black, although carbonaceous blacks cannot be excluded. The Aquatec line contained a single black, *Mars Black*, that by XRF is relatively pure iron with only trace amounts of other commonly associated metals such as chromium, manganese and copper. The black paint on the two Newman works have very similar elemental signatures and therefore may be the *Mars Black* paint.

3.3 Red Paint

Red paint is present on four acrylic paintings, *The Way II* (1969), *Be I (Second Version)* (1970), *Unfinished Painting* [*Red & White 1970*],

Unfinished Painting [*Blue & Brown 1970*] (1970), one oil painting, *White and Hot* (1967), as well as two canvas fragments, two paint rollers, the woven straw hat and a set of tweezers from the CTMS collection. Several samples of red paints present in Newman's studio at the time of his death are available: four jars of unlabeled red acrylic paint held by the CTSM, three jars of unlabeled acrylic paint donated by Robert Murray to the Menil Collection.

The bright orange-red paint on *White and Hot* contains barium, cadmium, sulfur, and selenium, suggesting a cadmium sulfoselenide pigment with barium sulfate as an extender. At the time period when *White and Hot* was created Bocour offered two different oil paint lines, Bocour Artist Oil Colors and Bocour Bellini Artists' Oil Paints, the latter of which were machine ground and less expensive (Bocour n.d. a). Samples of Bocour Artist Oil Colors *Cadmium Orange, Cadmium Red Light,* and *Cadmium Red Medium* and Bellini Artists' Oil Paints *Cadmium Red Light* and *Cadmium Orange* were available for comparison. Bocour Artist Oil Colors *Cadmium Orange* can be ruled out as a match for the red paint on *White and Hot* as this paint contains high levels of chromium and lead, suggesting that lead chromate is present. Unfortunately, comparison of the Cd/Se or Cd/Ba ratios of the paint on the painting with the historic Bocour paints reveals no exact analog. This could mean that the paint on *White and Hot* is a different formulation from the commercial paints, but the different elemental ratios detected could also result from different thicknesses of paint on the painting versus the study collection samples, modification of the paint by addition of medium, or a different batch of commercial paint.

The spectra of red paints on the paintings and ephemera all display peaks indicative of cadmium sulfoselenide pigments. Of these, only *The Way II* and the red on the hat also appear to contain barium sulfate, a filler/extender found in Aquatec *Cadmium Red Light, Cadmium Red Medium,* and *Cadmium Red Deep* paints and in Liquitex *Cadmium Red Light* (Epley and Rogge 2016). None of these samples contains significant amounts of lead, which is found in relatively high levels in the Aquatec paints *Cadmium Red Deep*, *Cadmium Red Light*, and in some samples of *Cadmium Red Medium*. As different samples of *Cadmium Red Medium* from the same address (NY 19) contain very different amounts of lead, it appears that the Aquatec formulations were not static and may have altered with time. Therefore, the absence of lead in the red of *The Way II* and on the hat cannot definitively exclude these paints from being Aquatec paints. However, while the Ba $L_{\beta 3}$/ Cd K_{α} ratios of the red on *The Way II* resemble some of the *Cadmium Red Medium* paints analyzed (0.8–0.9 and 0.7–0.8, respectively) (fig. 3) the Se K_{α}/Cd K_{α} ratios are sufficiently different (7.2–7.4 for the painting and 5.5–5.6 for the Aquatec paints) (fig. 4) to suggest that the paint on *The Way II* is not a standard Aquatec *Cadmium Red Medium* paint. Similarly, the peak ratios for the red on *The Way II* exclude Liquitex *Cadmium Red Light* as the paint source. The peak ratios of the red paint on the hat do not correspond to

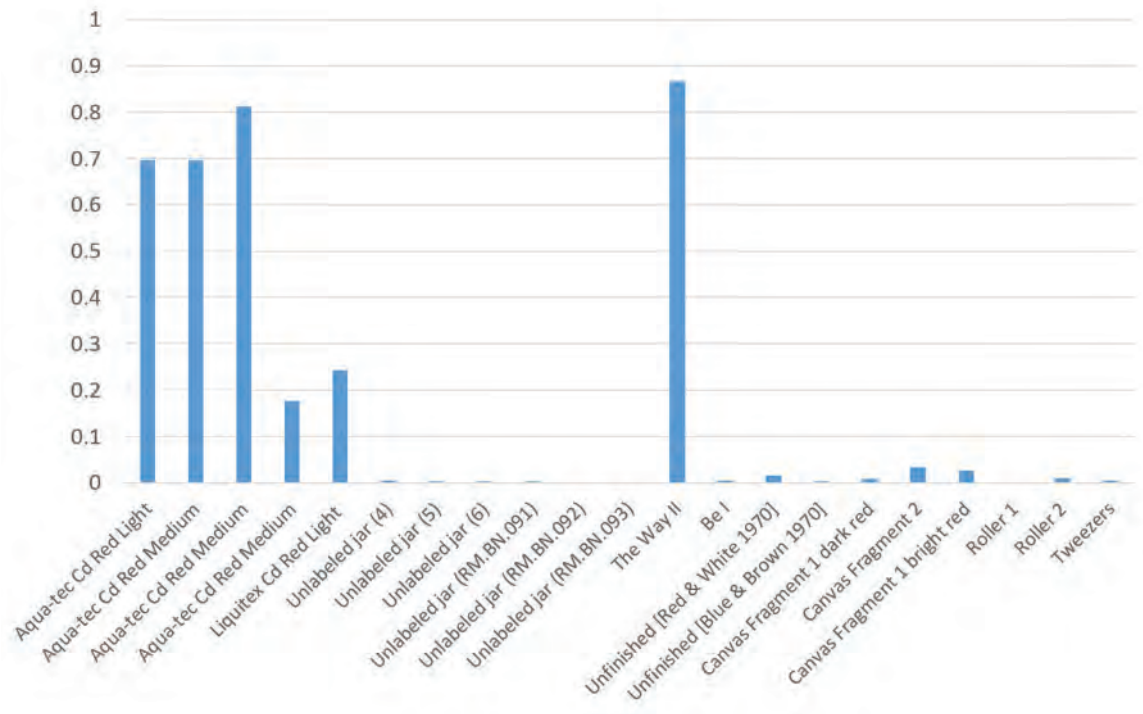

Figure 3. Ba $L_{\beta 3}$/ Cd K_{α} ratios of red cadmium sulfoselenide acrylic paints from historic Aquatec and Liquitex paint samples, unlabeled jars of paint from Newman's studio, and paintings and ephemera.

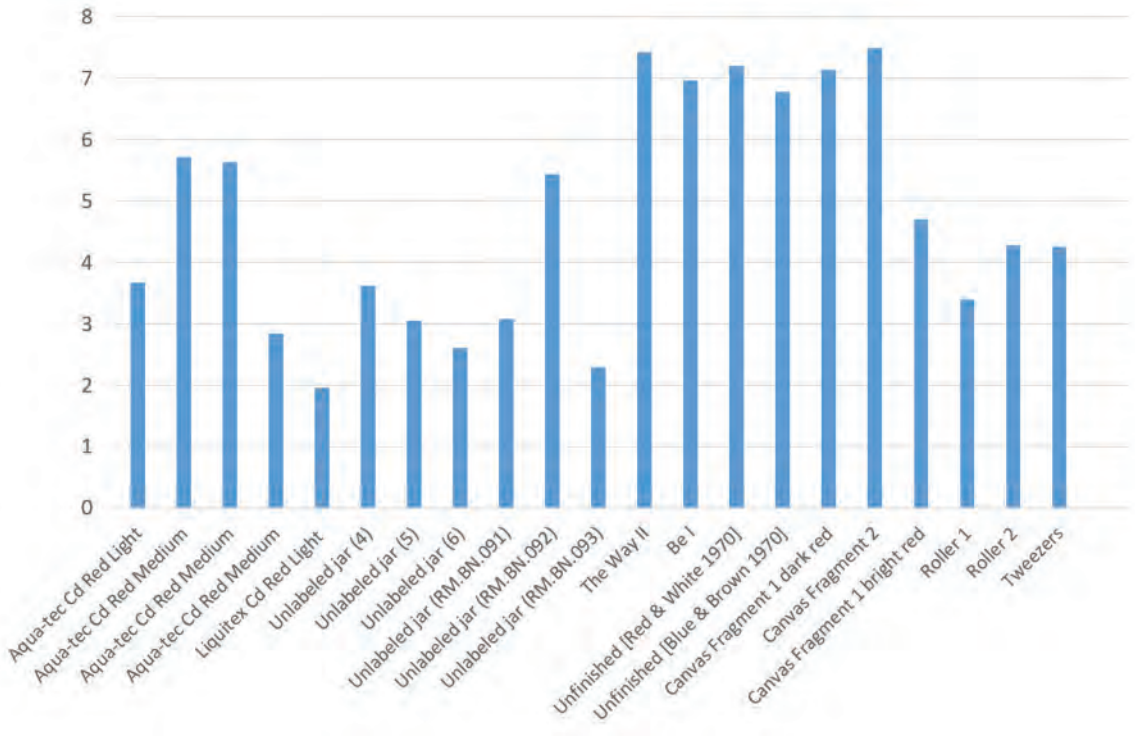

Figure 4. Se K_α/Cd K_α ratios of red cadmium sulfoselenide acrylic paints from historic Aquatec and Liquitex paint samples, unlabeled jars of paint from Newman's studio, and paintings and ephemera.

any of the commercially available paints that were available for analysis; nor do they correspond to the red paint on *The Way II*. None of the unlabeled jars of red paint contains significant amounts of barium and, therefore, does not correspond to the red paint on the hat or on *The Way II*.

The red paints on *Be I (Second Version)* (1970), *Unfinished Painting* [*Red & White 1970*], *Unfinished Painting* [*Blue & Brown 1970*] (1970), and two canvas fragments, two paint rollers, the woven straw hat and a set of tweezers from the CTMS collection do not contain barium sulfate, and therefore cannot be a standard commercial Aquatec or Liquitex paints. As previously reported, receipts from the Barnett Newman Foundation Archives for 'special' cadmium red paints suggest a formulation created for Newman (Epley and Rogge 2016), so perhaps these paintings and objects contain bespoke paint. The unlabeled jars of paint might be these specially commissioned materials, since their cadmium sulfoselenide paints contain only trace amounts of barium (fig. 3). The calculated Se K_α/Cd K_α ratios divide the red paints into two different groups (figs. 5 and 6): the paintings, the bichromatic red and white canvas fragment, and the dark red on the trichromatic red and white canvas fragment show high Se/Cd ratios, whereas the bright red on the trichromatic canvas fragment, the paint rollers, and tweezers display a lower Se/Cd ratio. The presence of both types of paint on the trichromatic canvas fragments suggests that both mixtures were used contemporaneously in Newman's studio in 1970. Therefore, although the Ca K_α/Ti K_α ratio of the white paints could not tie the two red and white canvas fragments to other paintings, the results from the red paints suggest that the destroyed painting(s) from which these fragments derive were created in 1970. Comparison of the ratios from the paintings and ephemera with those of the unlabeled jars of paint shows that unlabeled jar 4 from CTS-MA is a good match for the lower ratio group. However, there is no clear match for the higher ratio group; the ratio of RM.BN.092 is closest but likely does not correspond to the paint on those objects.

3.4 Blue Paint

Three paintings, *Untitled I* (1970), *Midnight Blue* (1970) and *Unfinished Painting* [*Blue & Brown 1970*] (1970), have blue acrylic paints, *Voice of Fire* (1967) has Magna, and two paintings, *Shimmer Bright* (1968) and *Midnight Blue* (1970), have oil paint. Historic Bocour paints available for comparison included Bocour Artists Oil Colors *Bocour Blue, Cerulean Blue,* and *Cobalt Blue*, Bellini Artists' Oil Colors *Prussian Blue, Bellini Blue, Ultramarine Blue, Cobalt Blue,* and *Manganese Blue,* Hand Ground Oils *Ultramarine Blue*, a sample of Magna *Ultra Blue* and an unlabeled blue in the Menil collection, and Aquatec *Ultramarine Blue* and *Cerulean Blue*.

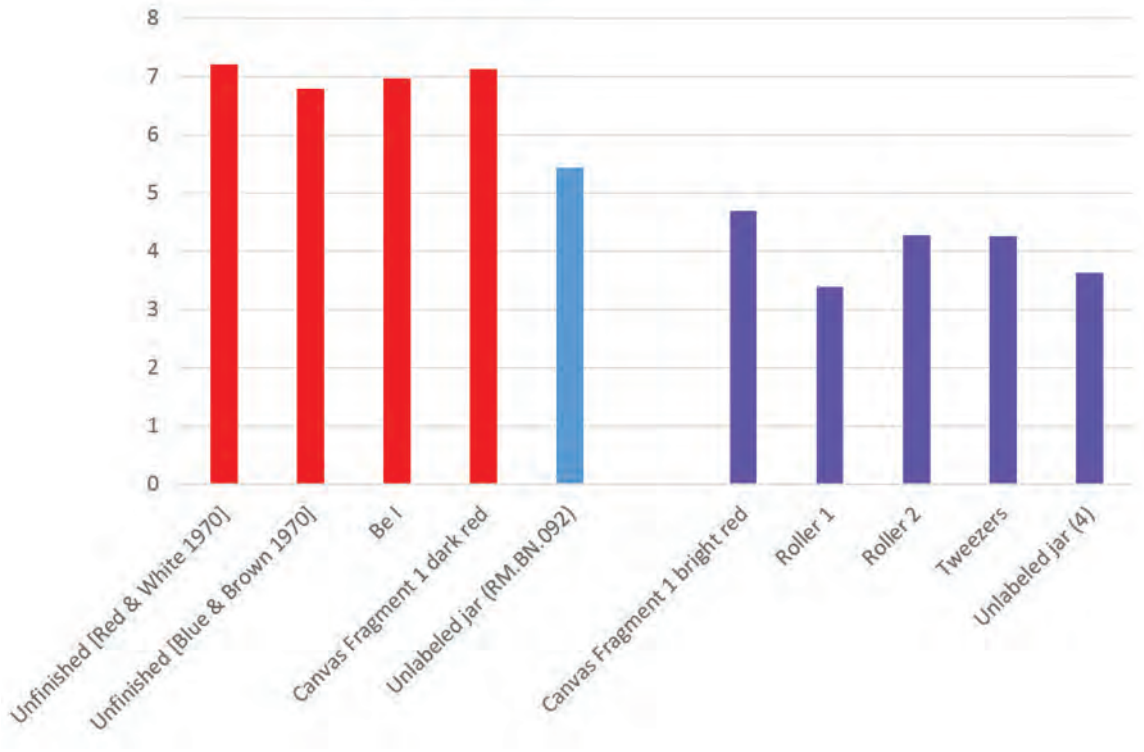

Figure 5. Se K_α/Cd K_α ratios of acrylic red cadmium sulfoselenide paints that do not contain barium sulfate as a filler/extender. The ratios identify two groups: one with a high ratio ~7 (red) and another with a lower ratio (~4).

The acrylic paintings contain a wide variety of different blue pigments, many in quite complex mixtures (Table 1). The blue on *Unfinished Painting* [*Blue & Brown*] is the simplest with phthalocyanine blue as the sole identified blue pigment. The subsurface blue layer on *Untitled I* contains high levels of cobalt, tin and chromium, suggesting a mixture of cobalt chromate and cobalt stannate cerulean blue. However, Newman revised his color choice on this painting and repainted the blue area; the surface blue appears to be primarily phthalocyanine blue, perhaps the same paint present on *Unfinished Painting* [*Blue & Brown*]. The blue on the blue and white canvas fragment from the Menil collection is pigmented primarily with a mixture of cobalt stannate and cobalt chromate cerulean blue, perhaps with a small amount of phthalocyanine blue added. The dark blue acrylic paint on *Midnight Blue* seems to be primarily phthalocyanine blue given the high levels of copper, but additional materials including phthalocyanine green and cobalt chromate cerulean blue may be present given the chlorine, cobalt and chromium detected. In contrast, the dark blue paint on *Voice of Fire* is likely made from a mixture of cobalt blue, ultramarine, and phthalocyanine blue, perhaps with a small amount of Prussian blue; the former three colors were all available in the Magna line (Upright 1985), but unfortunately historic samples were not available for analysis. These results suggest that Newman carefully crafted the tone and color of his blues by mixing different blue paints.

The Aquatec *Cerulean Blue* paint is cobalt chromate based, with no detectable tin. Therefore, if the formulation did not change over time, it is unlikely that Newman used Aqua-tec *Cerulean Blue* in *Untitled I* or the blue and white canvas fragment. The sample of Aquatec *Bocour Blue*, which utilized phthalocyanine blue as the pigment, has significant lead levels, perhaps as a biocide. Lead was not detected in the blues of any of these paintings, suggesting that the Bocour paints may not have been used, although the levels could be below the detection limit or the formulations changed through time. The aluminum, silicon, and sulfur ratios of the blue paint on *Voice of Fire* do resemble those of Aquatec *Ultramarine Blue* paints, suggesting that this material may have been used to create that blue mixture. It therefore seems that for many for his late paintings Newman may not have been using commercially available Aquatec blue paints.

Glass jars of unlabeled blue acrylic paint were present in Newman's studio at the time of his death. Two were donated by Robert Murray to the Menil Collection, and three jars were preserved in the CTSMA collection. Jar RM.BN.089 from the Menil contains a cobalt chromate cerulean blue-pigmented paint that contains no detectable tin. Therefore, unless Newman mixed this material with a cobalt stannate cerulean blue, it is unlikely to be the paint

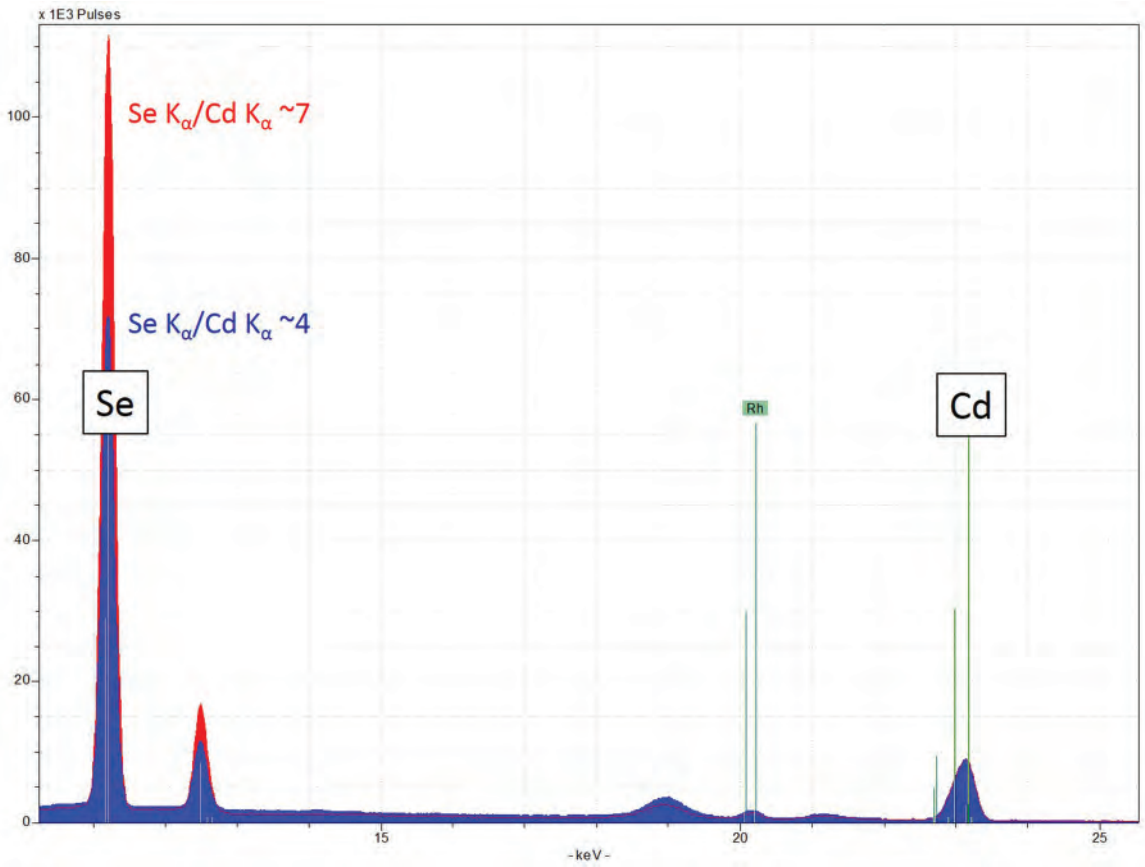

Figure 6. XRF spectra of two representatives from the different groups of paintings with distinct Se K_α/Cd K_α ratios; *Unfinished Painting* [*Red & White 1970*] (1970) (red); canvas Fragment 1 from the CTSMA collection (blue).

on *Untitled I* or the canvas fragment. However, it does resemble both the sample of Aquatec *Cerulean Blue* and Jar 2 from the CTSMA collection (fig. 7), although *Cerulean Blue* contains lead and the Cr K_α/Co K_α ratios are slightly different (0.74 for the jar paints, 0.9 for the Aquatec *Cerulean Blue*). The close similarity between the jars and the Bocour materials may indicate that the glass jars contain bulk Bocour Aquatec paints. Jar RM.BN.90 contains an ultramarine blue paint with a similar elemental profile to Aquatec *Ultramarine Blue* (fig.8) and to jar 1 in the CTSMA collection, although there are slight differences in titanium and iron signals. Jar 3 from the CTSMA collection has high levels of cobalt and zinc, suggesting the presence of a cobalt zinc blue, and closely resembles the Aquatec *Cobalt Blue* paint (fig. 9), although the latter contains lead. The slight differences could reflect changes in formulation through time, or indicate that Newman was asking for slightly modified paints, perhaps without the lead biocides. Newman was notoriously concerned about lead poisoning, and took care to wear gloves and protect himself from lead-containing paint (Mancusi-Ungaro 2004) so such a request would not be inconceivable.

The blue oil paints on the zips of *Shimmer Bright* and *Midnight Blue* are likely phthalocyanine blue paints given the elevated copper levels present in the blue zips. However, the dilute manner in which the blue paint was applied precludes comparison with the historic samples of Bellini *Bellini Blue* and Artists Oil Colors *Bocour Blue* phthalocyanine blue paints.

3.5 Yellow Paint

Yellow Edge (ca. 1968) contains yellow paint as does the woven brimmed hat from the CTSMA ephemera collection. Close inspection of images of the turnover edge of the canvas of *Yellow Edge* hints at the presence of at least two distinct layers of yellow paint, which suggests that Newman was unhappy with the tonality of the deeper yellow underlying paint and applied a lighter toned yellow on top, similar to alterations made in two other late paintings, *Unfinished Painting* [*Red &*

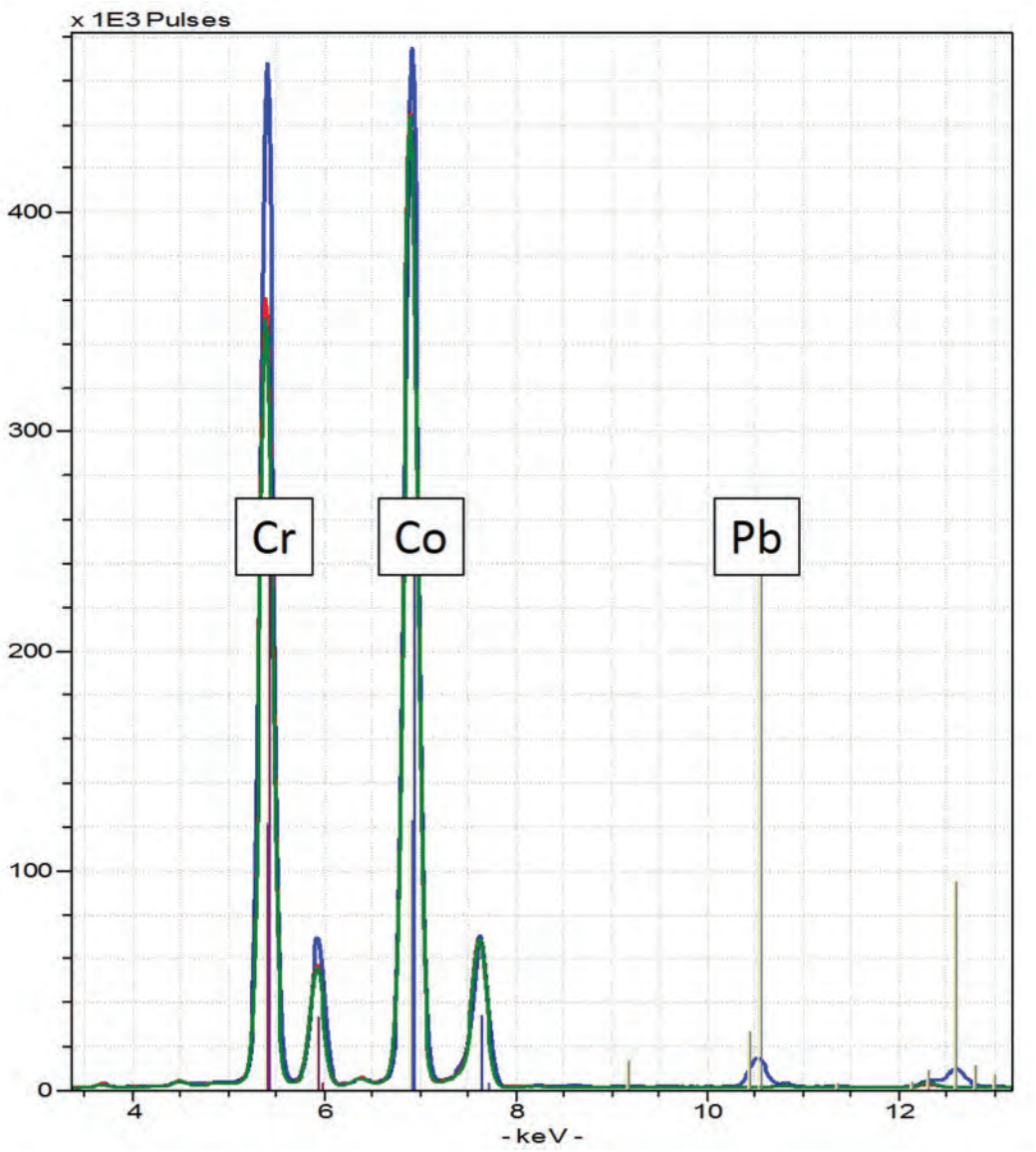

Figure 7. XRF spectra of blue paints: jar RM.BN.089 (green), Jar 2 from CTSMA (red) and Aquatec *Cerulean Blue paint* (blue). All three spectra indicate the presence of Cr and Co, however the Aquatec *Cerulean Blue* contains lead, and element not detected in the other two paints.

White 1970] (1970) and *Untitled I* (1970) (vide infra, Epley and Rogge 2015). Both yellow paints on *Yellow Edge* contain cadmium, sulfur, barium, and chlorine suggestive of a mixture of cadmium sulfide yellow containing barium sulfate as a filler and Hansa yellow. The surface paint also appears to contain titanium white based on elevated titanium levels. The paint on the hat contains sulfur, cadmium and barium, indicating that it too may be a cadmium yellow paint.

Historic Liquitex paints found in Newman's studio include *Cadmium Yellow Light* and *Cadmium Yellow Medium*, but the strong zinc signals detected in these paints suggests that the pigment is actually zinc cadmium sulfide. The yellows on *Yellow Edge* and the hat do not have high levels of zinc, and so are not Liquitex cadmium yellows. Aquatec paints analyzed include *Cadmium Yellow Light*, *Cadmium Yellow Medium*, *Cadmium Yellow Deep* and *Hansa Yellow Deep*. The *Cadmium Yellow Light* and *Medium* paints both contain cadmium, sulfur, and barium, suggesting cadmium sulfide and barium sulfate are the main inorganic constituents. The *Cadmium Yellow Deep* paint also contains selenium, indicating the presence of cadmium sulfoselenide. As selenium was not detected in the paints on

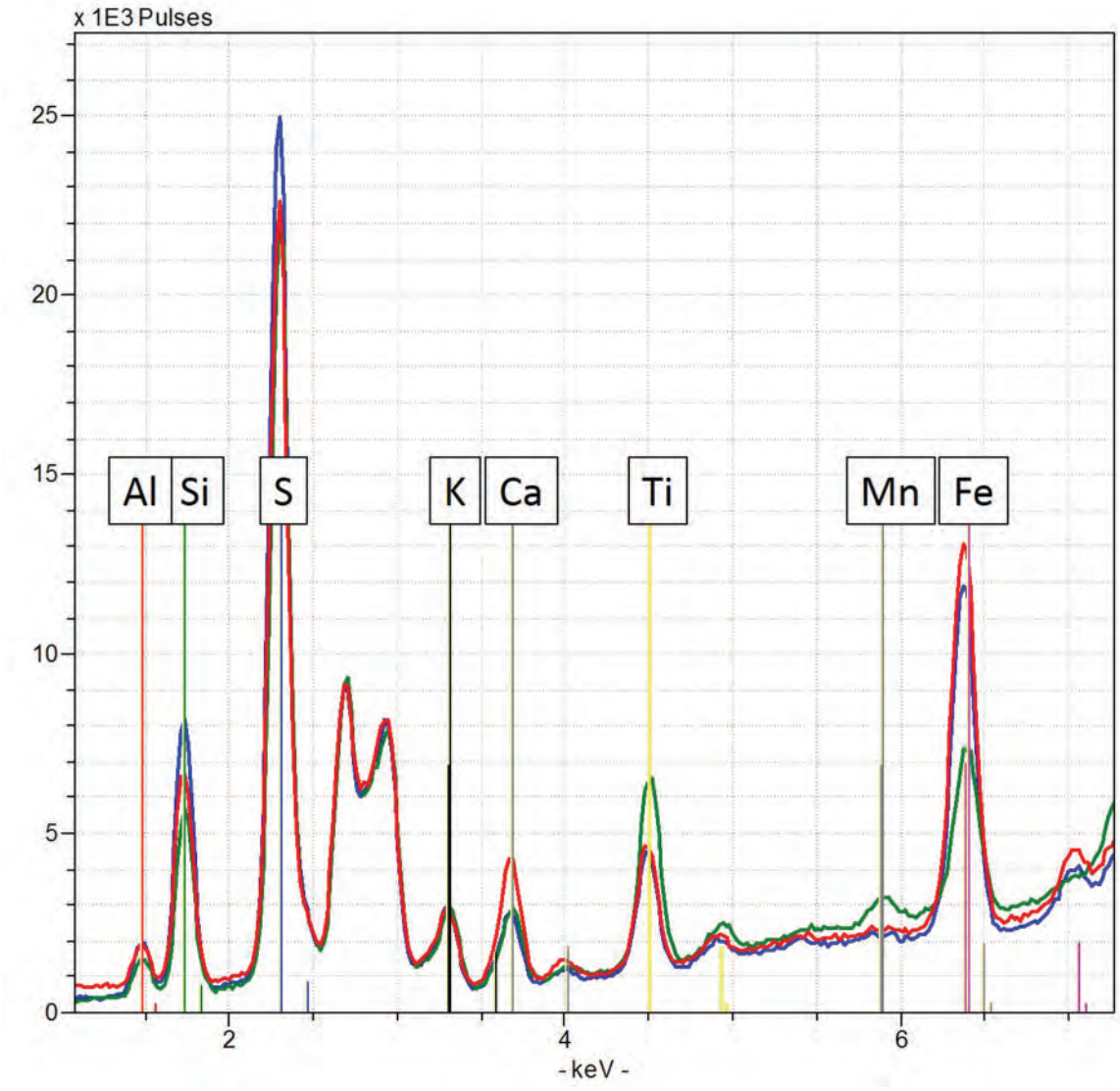

Figure 8. XRF spectra of jar RM.BN.090 (red), Jar 1 from CTSMA (blue) and Aquatec *Ultramarine Blue* paint (green). Aquatec *Ultramarine Blue* has the strongest Ti signal but the weakest signals for Si, and Fe; it also has detectable levels of Mn.

Yellow Edge or the hat, the use of *Cadmium Yellow Deep* can be excluded. The Cd $L_{\alpha 1}$/Ba L_3 peak ratios (which avoids contributions from Ti) of the paint on the paintings most closely resemble those of the *Cadmium Yellow Medium* paint (0.69 and 0.55, respectively) but are not close enough to permit firm identification. The *Cadmium Yellow Medium* and perhaps the *Cadmium Yellow Light* Aquatec paints also appear to contain Hansa yellow (PY1), based upon Raman spectroscopy (Rogge and Epley 2016), and recipe cards for other Bocour paints suggest the frequent addition of organic dyes to expensive cadmium colors (Bocour n.d. b). However, the amount of added toner in the paints is below the detection limit of the XRF and cannot account for the high chlorine levels present on *Yellow Edge*. Therefore, if Newman was using Aquatec *Cadmium Yellow Medium*, he must have deliberately mixed a Hansa yellow containing paint with the cadmium paint. The Hansa yellow paint is unlikely to be the *Hansa Yellow Deep* Aquatec paint as it contains much less chlorine than is present on the painting. The Cd $L_{\alpha 1}$/BaL_3 ratios of the yellow paint on the hat most closely resemble those of the *Cadmium Yellow Light paint* (0.36 and 0.27, respectively). The different in peak ratios and absence of chlorine mean that the paint on the hat corresponds to neither of the paints present on *Yellow Edge*.

3.6 Orange Paint

Voice of Fire (1970) contains a central band of a very intense orange-red paint that contains cadmium, sulfur, selenium, barium and mercury. Therefore, this paint could be either an orange

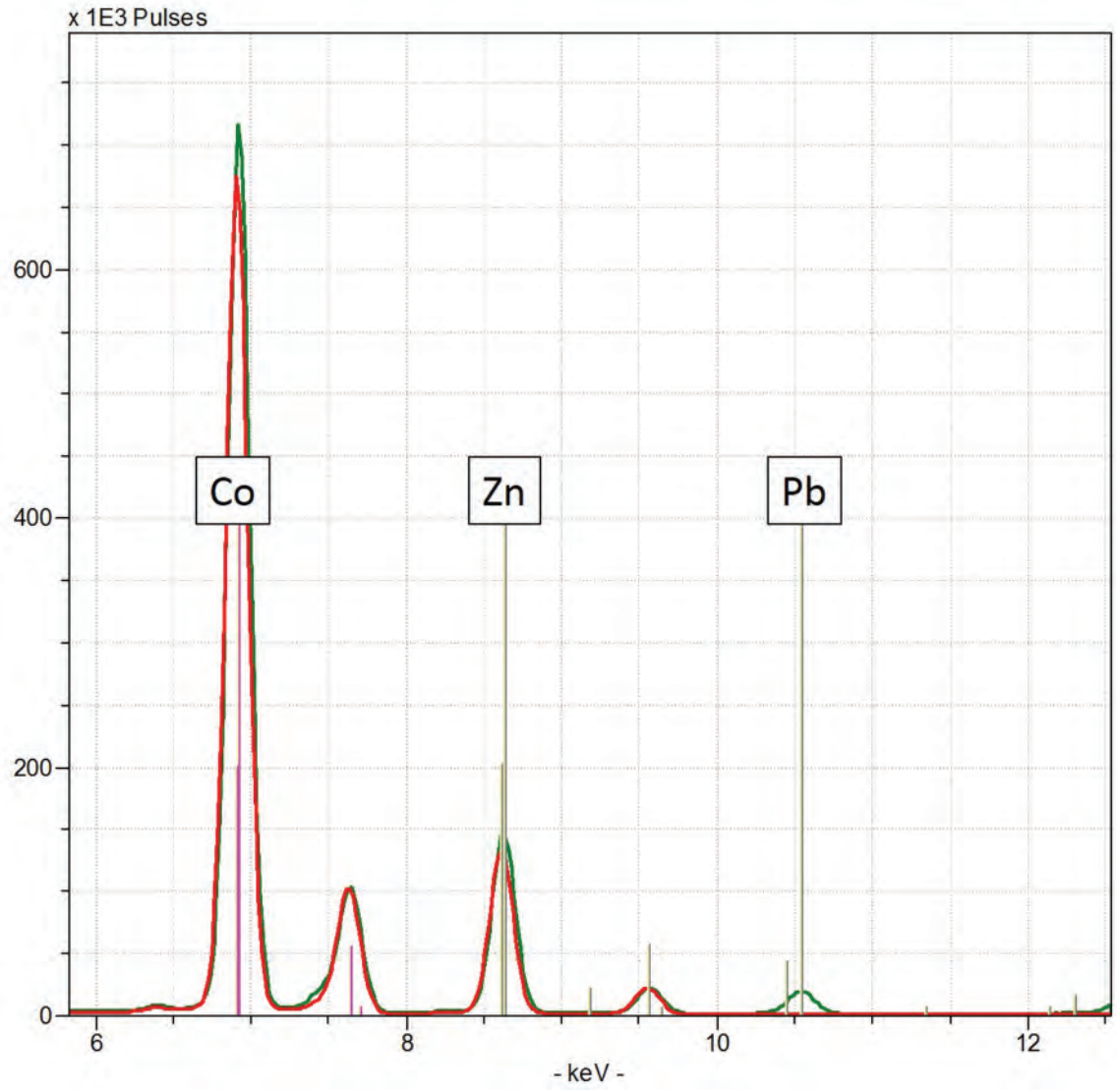

Figure 9. XRF spectra of Jar 3 from CTSMA (red) and Aquatec *Cobalt Blue* paint (green). The spectra are very similar in the 6–10 keV range but *Cobalt Blue* paint has Pb, an element that is not detectable in Jar 3.

cadmium sulfoselenide pigment with mercury as an anti-microbial additive, a cadmium sulfoselenide that has had vermillion added to it, or cadmium vermillion, a cadmium mercury sulfide pigment first patented in 1955 (US 2878134 A). The paint medium is indicated as being Magna in the catalog raisonné, and although the Magna paint line offered *Cadmium Orange, Cadmium Red Light*, *Cadmium Red Medium*, and *Cadmium Red Deep*, no paint-outs of historic samples were available for XRF analysis. For comparison, the paint on *Voice of* Fire was also compared with *Cadmium Orange* Aquatec paint. The Aquatec paint contains cadmium sulfoselenide and the Cd/Se and Cd/Ba are very similar to the paint present on *Voice of Fire*, however it does not contain mercury but instead has lead. Therefore, it is unlikely that the paint on *Voice of Fire* is an Aquatec orange paint.

3.7 Brown Paint

Unfinished Painting [*Blue & Brown 1970*] (1970) is the only one of the late paintings analyzed to have a brown paint, which overlies a cadmium red layer and so represents another instance where Newman revised the color of his composition. The Aquatec line offered four brown paints, Raw Sienna, Burnt Sienna, Raw Umber, and Burnt Umber; a paint-out of only one, Raw Umber, was available for XRF analysis. The Aquatec Raw Umber contains a higher manganese to iron ratio than the paint on *Unfinished Painting* [*Blue & Brown 1970*] (1970) and contains lead, an element absent in the spectrum of the painting. Therefore, it does not appear that the brown paint on *Unfinished Painting* [*Blue & Brown 1970*] is Aquatec Raw *Umber*.

4. CONCLUSIONS

Barnett Newman said in an interview "It is interesting to me to notice how difficult it is for people to take the intense heat and blaze of my color…I have never manipulated colors- I have tried to create *color*." (Gees Seckler 1962). To achieve those specific tones – the stark contrast of *Now II*, the vivid hues of *White and Hot*, or the more subtle palette of *Unfinished Painting* [*Blue & Brown 1970*] – Newman made conscious choices about which paints to use and how to mix them; in at least three cases in his late work, he revisited and revised his colors (Epley and Rogge 2015). The work presented here shows that Newman used a range of materials, and that while he may have used Bocour paints, he rarely used them in an unmodified fashion; more often it appears that he mixed colors or had bespoke paints made to suit his requirements. This understanding of Newman's materials re-affirms the care that he took in crafting his color choices and creating paintings. In addition to gaining a better understanding of his paints, the detection of specific pigment and specific pigment ratios within the paints permits the creation of material links, which in turn suggests temporal links. As Newman was notoriously secretive and never allowed others to see him paint, these links may be the only way to determine the relationship between his different paintings.

ACKNOWLEDGEMENTS

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NOTE

1. The proper names of the paints are capitalized and italicized to distinguish names from pigments or generic paint names.

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InVia Raman microscope
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5277 Trillium Blvd
Hoffman Estates, IL 60192
847-286-9953
http://www.renishaw.com

Lumos FTIR microscope
Bruker Optics Inc.
19 Fortune Drive
Manning Park
Billerica MA 01821
978-439-9899
https://www.bruker.com

Nicolet Nexus 670 FTIR spectrometer and Omnic software
Thermo Fisher Scientific
81 Wyman Street
Waltham, MA 02451
800-556-2323
http://www.thermoscientific.com

PM100D laser power meter and S120C photodiode power sensor
ThorLabs
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EMILY PREHODA and JOSEPH R. SWIDER

An Investigation into the Materials and Techniques in Francis Picabia's *La Terre est Ronde*, 1951

ABSTRACT

This article explores Francis Picabia's materials, intentional alterations to the composition, and unexpected condition issues present in La Terre est Ronde, *1951. Pentimenti were compared to a previously identified source image of a black-and-white reproduction of the Angel from the Seventh Seal of the Apocalypse from a 10th century Catalan manuscript. X-ray radiography confirmed that Picabia omitted anatomical aspects of the source figure as he originally painted it, and reworked it to create a fully abstracted form. Condition issues included a network of open cracks in the green circles and small crystalline efflorescences in the blue background, which merited scientific analysis.*

1. INTRODUCTION

La Terre est Ronde, 1951, oil on canvas (fig. 1), is one of the last paintings, if possibly the very last painting, Francis Picabia created before he became so infirm that he could longer paint until his death in 1953. His wife, Olga Picabia (née Mohler), stated, "The desire to live that animated him in every picture made him paint ten works…. *Villejuif* and seven others he christened with the names of the days of the week. And the last of all was *The earth is round* [*La Terre est Ronde*]" (Borràs 1985). Other art contemporaries also backed this statement (Felix 1998, Picabia 2002).[1] Thus this painting is very likely Picabia's last work, though this has not yet been confirmed, and may not ever be concretely determined, as it is possible he may have carried out numerous works simultaneously. However, *La Terre est Ronde* is very representative of Picabia's late works, as well as his propensity for experimentation and his rather irreverent attitude toward the established art world, as well as his own works, throughout his career.

Figure 1. Francis Picabia, *La Terre est Ronde*, 1951, oil on canvas, 32 × 25 ⅝ in. (81.3 × 64.8 cm); after treatment

Picabia experimented with a variety of paints and mixed media materials throughout his œuvre. He often employed ready-made commercial paints in addition to traditional artist's oil paints, commonly repainting or completely painting over his compositions, and he also incorporated 3D objects onto some of the paintings. His painting techniques and use of nontraditional materials often have resulted in confronting unexpected aspects and condition issues in his works as they have aged.

Anticipation of a forthcoming loan necessitated conservation treatment to address structural and aesthetic concerns; however,

as examination of the painting progressed, it became clear that a number of unexpected materials and techniques were present in this painting. It appeared that these condition issues likely resulted from Picabia's paint materials, as well as his practice of repainting areas or entirely overpainting his earlier compositions.

Examination of the material nature of this painting also revealed the artist's specific alterations to the composition. Picabia commonly used a variety of mass-produced images as sources for his paintings throughout his artistic career, ranging from mechanical drawings to contemporary advertisements (Clements 2013). Previous art historians have identified Picabia's widespread use of source imagery throughout his œuvre. Yet, the dichotomy of Picabia's reference of classical and religious artworks, which he used as inspiration to create irreverent, abstract paintings, remains a cause for intrigue. While the source image for *La Terre est Ronde* was previously identified, and will be discussed further subsequently, the precise extent to which Picabia initially replicated this original image on his canvas, or repainted over preliminarily applied figural components, remained unknown. Thus art historical and scientific research was carried out to understand Picabia's creation of one of his final artworks better.

2. EXAMINATION AND CONDITION

The painting presented with three primary condition concerns: a significant, closely spaced network of open cracks in the two green painted circles; discolored retouching over a poorly textured, filled inverted L-shaped tear at lower left; and white crystalline efflorescences on the blue paint at the upper right quadrant.

Examination techniques employed included inspection under the microscope, with UV illumination, and with IR photography. When viewed under the microscope, the open cracks in the green paint revealed underlying red, yellow, and blue paint layers (fig. 2). Microtests were performed under the microscope to determine materials and techniques that may possibly be employed in treatment. The complexity of the painting's construction and condition became more evident, and testing and resulting observations indicated that the green paint was particularly sensitive to a variety of commonly employed conservation consolidants. Detailed examination, paint-sensitivity testing results, and literature research suggested this green paint, and possibly other paint colors, may not be a traditional oil paint, and may be a proprietary house paint,

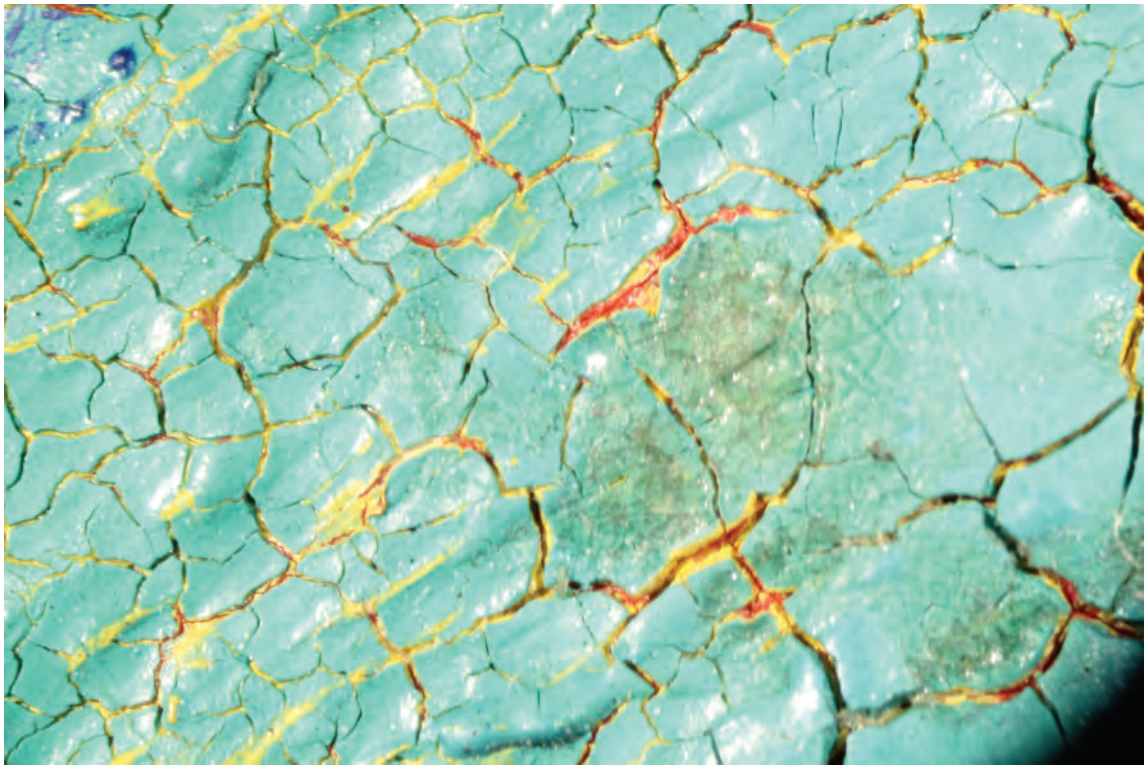

Figure 2. Detail of cracks in green painted circles, revealing underlying red, yellow, and blue paint layers. Francis Picabia, *La Terre est Ronde*, 1951

Figure 3. Detail of previously repaired tear (1 × 1 in.) at lower left, poorly textured fill, and discolored retouching that extended slightly beyond the edges of the loss; before treatment. Francis Picabia, *La Terre est Ronde*, 1951)

such as Ripolin (King et al. 2013). Scientific analysis was critical to obtain a more informed and ethically responsible approach to treatment to improve the painting's condition and stability, particularly regarding the sensitivity and extensive cracking of the green paint.

A filled and inpainted inverted L-shaped tear (fig. 3) was located at the painting's lower left quadrant in the white and light blue "earth." The inpainting had discolored over time, and the fill was poorly textured and had become visually detracting from appreciation of the image. The tear occurred at an unknown time and, along with weak and torn areas of canvas fibers regularly visible along the painting's edges where it turns over the stretcher, likely necessitated the overall canvas lining.

Small white specks on the dark blue paint at the upper right quadrant were not readily obvious when the painting was examined onsite, and it was unclear if they were inherent small white paint dots, or an possibly an efflorescence or exudate. However, upon examination under the microscope, these appeared to be crystalline in structure and likely to be an efflorescence, possibly a salt, as evidenced by solvent testing. These white specks have a branched, crystalline appearance under the microscope (fig. 4), and are not water-soluble. However, in varnish removal tests, these white crystals appeared to be soluble in aromatic solvents, but it is unclear if they were being entirely removed, or if they may continue to form in the future in voids of removed crystals. Scientific analysis was deemed necessary to obtain critical information on the exact nature of these crystals, and assist in determining how they should most appropriately be treated.

2.1 Paint Media

The paint is recorded as being an oil media, but no known scientific analysis had been previously carried out to confirm this. Numerous observations suggested that the painting may not comprise an oil paint alone and may contain other paint media, mixtures, or house paints, as Picabia was known to have experimented with a variety of painting materials.[2] The green paint has some inherent round voids, possibly created by air bubbles escaping as the paint dried, which may suggest that it possibly contained or was mixed with a water-based acrylic or a house paint, such as Ripolin brand paint. Ripolin is known to exhibit specific drying characteristics, such as a leveled smooth surface while drying, or have unusual drying defects, such as wrinkling and dripping (King et al. 2013). Additionally, the green paint was readily soluble to microtesting with swabs dampened with distilled water and saliva, which is atypical of an aged oil paint. However, the extensive cracking in this green paint layer may be a contributing factor to this aqueous sensitivity.

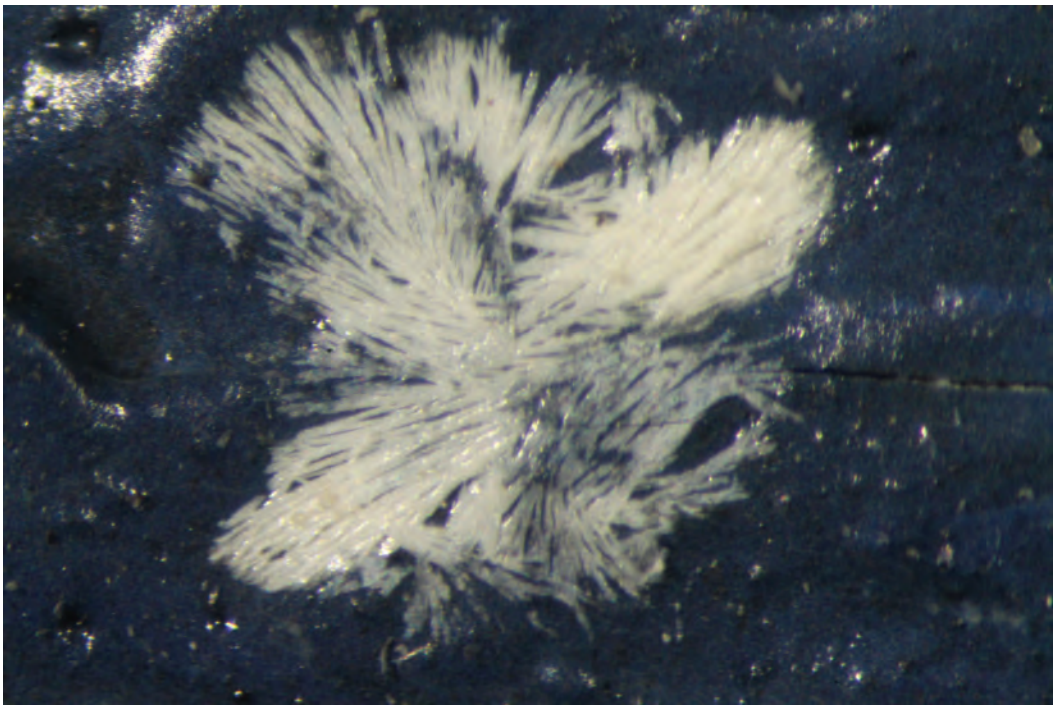

Figure 4. Photomicrograph of crystalline efflorescence at upper right quadrant. Francis Picabia, *La Terre est Ronde*, 1951

The deep blue painted background had numerous, small areas of intralayer cleavage (~¼ in. or less) scattered throughout the upper left quadrant, primarily near the upper edge. This paint appears smooth on the surface, but is quite granular and more vibrant blue where the smooth surface had been lost and the interior of the paint layer had been exposed. This indicated that the blue paint layer lacks sufficient medium and is poorly bound internally, and it may be susceptible to additional losses in the future. Matte blue retouching covers exposed ground and cleaved original blue paint in a loss near the upper edge, signifying that this intralayer cleavage was occurring prior to, or during, the previous restoration. Less than a dozen small, scattered voids throughout the dark blue paint layer exposed small dots of the white ground layer, for example, right of the central cylindrical form; these are inherent and should not be mistaken as micropaint losses or efflorescences.

2.2 Pentimenti

Photography with an IR filter revealed no preparatory drawing lines applied over the ground layer, and no IR detectable compositional changes in the painting (fig. 5). However, pentimenti—evidence of artist changes in the color or composition, or repainting over an earlier composition—are clearly visible under the microscope in numerous areas. An annotated image created by the author outlines areas of pentimenti visible in raking light, which indicate that Picabia's initially applied

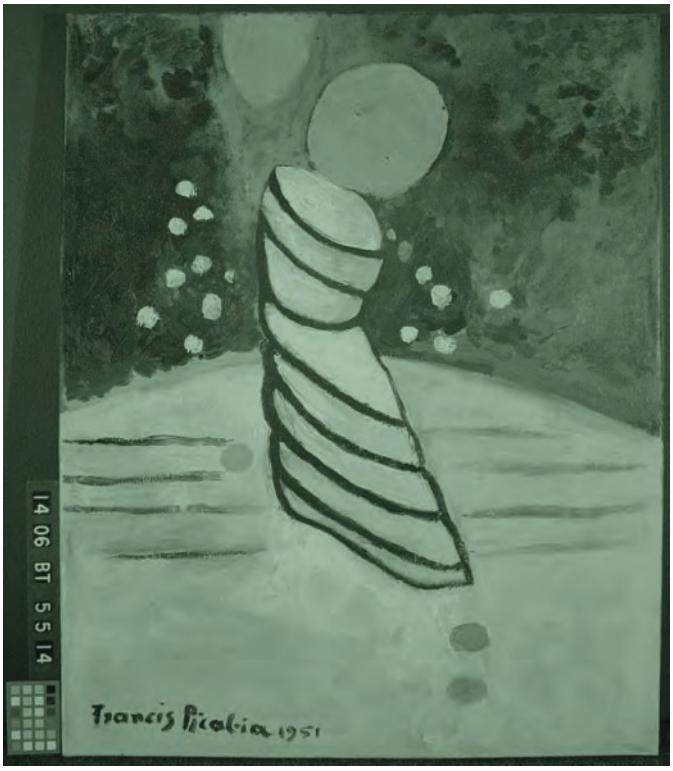

Figure 5. Infrared (IR) photo, before treatment. Francis Picabia, *La Terre est Ronde*, 1951

image had arms and legs extending from the white columnar form (fig. 6). X-ray radiography used in the course of examination to verify the initial figures and paint layers that Picabia applied during his creation, and recreation, of this image are further discussed subsequently. Beige-yellow paint is visible spanning between the top edge of the white form and the green circle above. Yellow, red, and blue paints are visible in cracks, voids, and areas not entirely coated by the green paint of the two large circular forms at upper center (fig. 2).

Differential drying of the underlying and overlying paint layers may have contributed to the extensive cracking of the uppermost green paint layer. A few displaced green paint fragments trapped in the varnish of the neighboring dark blue paint indicated that the paint instability was ongoing when the painting was previously cleaned and varnished.

Another visible area of pentimento is traces of vibrant blue paint visible through cracks in the overlying white paint layer at the lower right corner (3 × 1 in.) (fig. 7). This underlying blue paint appears as though it may have formed letters, possibly the artist's signature, or a date, which Picabia subsequently painted over. The examination techniques used during this study did not reveal any additional information about this area.

Figure 6. Annotated image of *La Terre est Ronde* outlined in red, based on and visible pentimenti during examination, source images, and x-ray radiography. Francis Picabia, *La Terre est Ronde*, 1951

Figure 7. Details of illegible inscription in blue paint, painted-over with white paint by artist, lower right corner. Francis Picabia, *La Terre est Ronde*, 1951

Examination with a wider or variable range infrared photography, or alternative methods, may further reveal information about these underlying paint layers in greater detail.

Art historian William Camfield identified *La Terre est Ronde* as having been sourced from a reproduction image of the Seventh Angel of the Apocalypse, from a 10th century illuminated manuscript by the Urgell Beatus, contained in the 1926 Folch y Torres exhibition catalog of a Catalan Roman art exhibition in Barcelona (Folch y Torres 1926) (fig. 8).[3] Art historian Candace Clements has further verified Picabia's use of numerous source images from this publication, from which the artist referenced numerous painting motifs throughout his life (Clements 2013). This image was most certainly viewed by Picabia, as he referred to it for a number motifs in over 50 identified works. One peculiar note is the very diminutive size of this source image from the original Torres publication, which measures approximately a mere 3 × 2 in. (7.6 × 5 cm) (fig. 9). It appears Picabia was fond of creating relatively quite large, impactful works based on small, rather illegible black-and-white reproduction images, emphasizing the essence of figures and forms he found most compelling.

2.3 Surface

The surface exhibited no distinct fluorescence indicative of a varnish when viewed under UV illumination (fig. 10). Nonetheless, two varnish layers visible under the microscope were distinguishable with microsolvent testing. A synthetic resin-type varnish layer, grayed with age, was applied over remnants of an aged, yellowed, natural resin-type varnish pooled in the interstices of the paint texture. It was unclear if the

Figure 8. Folch y Torres, J. 1926. *Junta de Museos de Barcelona, Museo de la cuidadela: Catálogo de la seccion de arte románico*. P11. The Angel of the Seventh Seal of the Apocalypse from the illuminated Urgell Beatus, 10th century Catalan artist. Photograph of book image.

Figure 9. Folch y Torres, J. 1926. *Junta de Museos de Barcelona, Museo de la cuidadela: Catálogo de la seccion de arte románico*. P11. The Angel of the Seventh Seal of the Apocalypse from the illuminated Urgell Beatus, 10th century Catalan artist. Photograph of book image with penny.

synthetic-type varnish covered the entire painting, or was only applied to the painting's lower half and the central white form.

Dislodged green paint fragments and fibers trapped on the blue paint's surface, in addition to a rather uniform surface sheen, suggested that a coating was indeed present. Testing with aromatic solvents did not distinctly remove a varnish coating on the blue paint, as opposed to obvious removal of a varnish in tests on the painting's lower half. The blue paint may have been porous enough that it absorbed any varnish applied, and thus no distinct coating was discernable or removable. Scientific analysis of a blue paint sample was requested to assist in determining if a coating was present.

Grime and aged varnish layers significantly dulled and darkened the painting's natural appearance. In addition, numerous small, white crystalline formations in the upper right quadrant, mentioned earlier in this text, resulted from an undetermined efflorescence process, which were unintended by the artist and visually distracting.

3. SCIENTIFIC ANALYSIS

Examination and photography under the microscope, as well as with UV and IR photography were used to investigate the materials, construction, and condition of *La Terre est Ronde*. Digital x-ray radiography[4] was also employed to better ascertain Picabia's materials and construction of the underlying paint layers, and to determine the extent of the fully formed original composition as it was initially applied by the artist, prior to his reworking of the image.

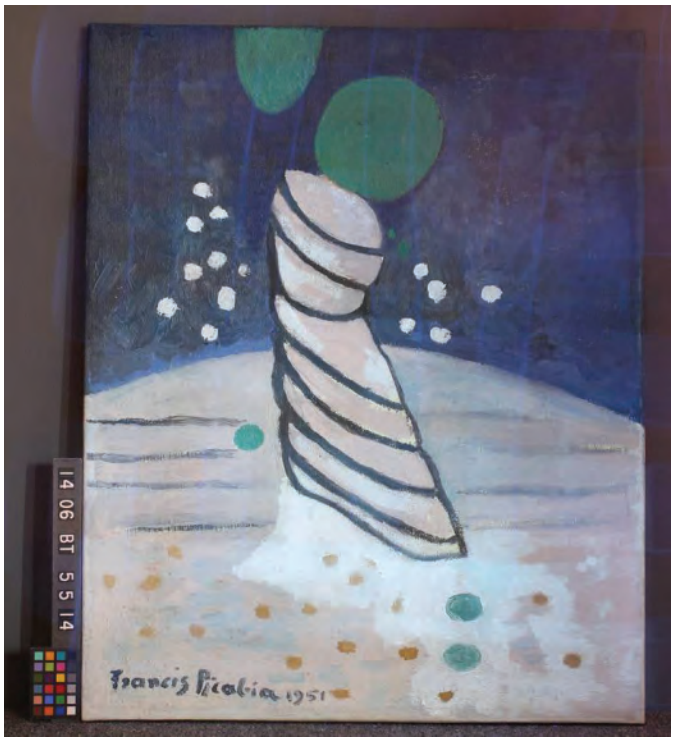

Figure 10. Ultraviolet (UV) illuminated photo; before treatment. Francis Picabia, *La Terre est Ronde*, 1951.

Scientific analysis was necessary to provide a better understanding of the painting's material nature and condition issues, and to determine conservation materials and techniques that could be employed to improve the painting's stability and appearance as best possible. The following five samples were taken for analysis.

1. *Scrapings of white crystals*: The nature and cause of the white crystals was unknown and required analysis to determine their composition. These were suspected to be an efflorescence, such as a salt, or another material. Sampling and analysis was intended to identify the white crystals' composition, and to assist in determining if these might be appropriate to remove, or if they will continue to form once removed from the surface. It is possible that removal could continue to degrade the paint layer by refilling microvoids at removal sites, and thus the crystals should be left untreated and simply retouched to eliminate their visibility. A sample scraping of this white material was taken from the upper right quadrant, without disturbing the underlying blue paint.
2. *Cross section of blue paint*: The dark blue paint at upper left has intra-layer cleavage, and it was unclear if a distinct varnish layer was present on the various shades of dark blue in the painting's upper half. Sampling and analysis of a cross section was intended to determine the pigments and binder of the dark blue paint, and also to determine if a distinct varnish coating is present on this paint. This aimed to identify the paint pigments and binder, and possibly provide information relating to the potential causes for the intralayer cleavage. A cross section was taken from the upper left quadrant.
3. *Cross section of green, and underlying red, yellow, and blue paint layers*: The two green painted circles at the center of the painting's top edge have extensive cracking, and underlying red, yellow, and blue paint layers that are sporadically visible through cracks and losses. This green paint, as well as the underlying paint layers, was suspected to potentially be Ripolin house paint, due to Picabia's previous use of this paint, and the unusual surface leveling and air bubbles visible (King et al. 2013). Sampling and analysis of the stratigraphy of a cross section aimed to identify the pigments and binder(s) of the green paint and underlying paint layers, and assist in determining the most appropriate method of stabilizing the cracked green paint. A sample was taken from the painting's upper edge where the canvas turns over the stretcher, and all colors were visible (fig. 2).
4. *Scraping of a possibly synthetic-type varnish*: Identification of the synthetic-type varnish layer was intended to facilitate the safest and most straightforward thinning and/or removal. It also assisted in determining if this varnish was present over the entire painting, when compared with the blue paint sampled near the upper edge. A scraping of the varnish was taken from the lower right quadrant.
5. *Scraping of possibly natural resin-type varnish*: The yellowed varnish remnants pooled in the interstices of the paint impasto, and collected in cotton fiber clumps from the previous varnish removal, appeared to be a natural resin-type varnish. Analysis aimed to provide additional information on the material nature of this varnish, providing clues as to when the varnish was applied, and to facilitate removal of these residues. A scraping of the varnish was taken from the lower left quadrant where the overlying synthetic-type varnish had been removed in testing. A clump of yellowed, varnish-embedded cotton fibers was also easily removed from the surface for analysis. A scraping was taken from the lower left quadrant.

Particles that composed each sample were initially examined using light microscopy (LM). Samples were then prepared for FTIR for organic characterization, SEM/EDS (energy-dispersive x-ray spectrometry) for elemental composition, and XRD for phase identification. Portions of samples 2, 3, 4, and 5 were pressed into a potassium bromide crystal for FTIR. Additional samples from materials in samples 1, 2 and 3 were

mounted on a beryllium stub for elemental analysis and imaging by SEM/EDS. Portions of samples 1, 2, 3, and 4B were mounted on a polymer mount for phase identification using XRD.

3.1 Results

A summary of the analytical analyses is provided in Table 1.

Sample 1: Elemental analysis of the white crystalline particles from all three samples showed similar profiles containing major lead (Pb) with some minor elements. Phase analysis by XRD confirmed these particles were a mixture of two forms of lead carbonate, sometimes referred to as white lead, cerussite ($PbCO_3$), and hydrocerussite ($Pb_3(CO_3)_2(OH)_2$).

Sample 2: The particles in this sample appeared blue; some contained a layer ("top layer") that was clear. Wood fibers appeared to be present in some particles. The top clear layer was approximately 20–30 μm in thickness and was identified as a polymer-based on poly(vinyl acetate) by FTIR. The blue layer varied in thickness from particle to particle and its elemental profile showed sodium (Na), aluminum (Al), sulfur (S), and silicon (Si) with scattered particles high in lead (Pb) or barium (Ba). Phase identification by XRD showed a major phase of lazurite or other similar sodium-aluminum-sulfide silicate. A trace phase of the titanium dioxide anatase was also probable. The common synthetic pigment for this phase is ultramarine blue, while the natural is lapis lazuli. The rather consistent particle size seen in the SEM, along with the lack of extraneous mineral phases in the XRD pattern, implies this is the synthetic pigment.

Sample 3: Five different colors were seen among the particles in this sample: green, blue, red, yellow, and white (fig. 11). A sample of each color was analyzed by SEM/EDS, FTIR, and XRD. The blue color was similar in elemental profile and phase to the sample 2 blue, showing lazurite (or similar silicate) with lead white. Lead white was also identified by XRD in the white particles. The elemental profile of the green particle contained barium (Ba), sulfur (S), and chromium (Cr), with minor and trace zinc (Zn), and lead (Pb). Diffraction revealed two major phases, barite ($BaSO_4$) (aka barium white) and hashemite ($Ba(CrO_4)0.8(SO_4)0.16$) (aka barium chromate); the barite was also confirmed by FTIR. Minium (Pb_3O_4), (aka lead red), was identified in the red pigment with some minor calcite, along with a stearate component. The yellow particle was identified as crocoite ($Pb(CrO_4)$), (aka chrome yellow), zincite (ZnO), and anatase with another phase that was similar to sodium phases, such as a carbonate or oxalate. Organic analysis by FTIR of the yellow particle also showed that a stearate was present.

Sample 4: Two particles showed a material similar to poly(vinyl acetate), (PVAc). A sample of white material from this sample was also analyzed using XRD. The sample showed three phases—hydrocerussite, anatase, and barite.

Samples 5: One particle analyzed by FTIR was similar to a methacrylate, bands at 1059 cm^{-1} and the OH band around 3408 cm^{-1} may indicate cellulose, likely from the cotton fiber embedded in the varnish surface. Other materials may be present; in particular, the band at 996 cm^{-1} could not be identified. A second particle showed a material similar to poly(vinyl acetate) (PVAc).

Digital x-ray radiography imaging verified the presence of a fully formed, underlying, and subsequently overpainted, image of the Angel of the Seventh Seal of the Apocalypse from the Folch y Torres 1926 publication (fig. 12). The annotated image created by the author, mentioned above, used information gained from pentimenti and the composite x-ray image, to show the anatomical features that were painted out by Picabia to create his final composition (fig. 6).

3.2 Treatment

The painting's main condition issues included extensive open cracks in the irregular green circles, poorly matched filling and inpainting, white crystalline efflorescences on the blue paint at the upper right quadrant, a dull yellowed varnish layer, and surface grime with numerous small accretions and cotton fibers trapped on the surface. Underlying layers of red, yellow, and blue paint were exposed by the open cracks in the green paint, visible under magnification. Adhesive and solubility testing under the microscope indicated the green paint exhibited sensitivity to a wide range of conservation grade adhesives commonly used for stabilization, as well as solvents tested for potential varnish removal.

Following scientific analysis, literature research, and testing, the green paint surrounding losses and along the open cracks in the circular shapes was stabilized with an acrylic resin adhesive[5] infused into the cracks under the microscope. Treatment increased the paint's stability without altering the surface sheen or proliferating cracks. Surface cleaning removed a dark gray grime layer, and revealed a subtly brightener and richer surface appearance.

Solvent testing of the dark blue paint on the painting's upper half did not appear to remove a distinct coating and did not result in an appreciable visible appearance. However, the presence of a thin, synthetic varnish layer was confirmed by scientific analysis. Small shallow losses in the blue paint, which were the result of intralayer cleavage of the poorly bound paint, may have been partially stabilized by the existing PVAc

Table 1. Summary of the LM, SEM/EDS, XRD, and FTIR Analyses

Sample	Particle	SEM/EDS Results	XRD Results	FTIR Results
1	A, B and C-white crystals	Major Pb, C, O; some areas with minor Na, Al, Si, S, Ti	Cerussite ($PbCO_3$) and hydrocerussite ($Pb_3(CO_3)_2(OH)_2$)	NA*
2	Blue	Na, Al, Si with small particles of Pb or Ba	Major phase of lazurite or other Na-Al-S silicate; probable minor to trace phase of anatase	Silicate material with some organic
	Clear varnish	NA	NA	Polymer-based on poly(vinyl acetate)
3	Green	Ba, S, Cr with minor to trace Zn, Pb	Barite ($BaSO_4$) and hashemite ($Ba(CrO_4)_{0.8}(SO_4)_{0.16}$	$BaSO_4$ with additional inorganic and organic material
	Blue	Na, Al, Si with small particles of Pb or Ba	Major phase of lazurite or other Na-Al-S silicate with cerussite ($PbCO_3$) and hydrocerussite ($Pb_3(CO_3)_2(OH)_2$	Silicate
	Red	Major Pb with minor Si, Ca, Fe	Major minium, $Pb3O_4$, and minor calcite	Possibly a stearate present (e.g., Pb stearate) with some silicate
	Yellow	Major Pb, Zn, minor Na, Ti, Cr	Crocoite $Pb(CrO_4)$, zincite (ZnO), and anatase (TiO_2); possible Na phase such as a carbonate or oxalate	Possibly a stearate present (e.g., Zn stearate)
	White	Major Pb	Cerussite ($PbCO_3$) and hydrocerussite ($Pb_3(CO_3)_2(OH)_2$	Lead white with small amount of organic
4	A-synthetic-type varnish	NA	NA	Similar to poly(vinyl acetate)
	B-synthetic type varnish with blue paint	NA	Hydrocerussite, anatase, and barite	Similar to poly(vinyl acetate)
5	A-Natural resin type varnish	NA	NA	Methacrylate, bands at 1059 cm^{-1} and OH around 3408 cm^{-1} may indicate cellulose; other materials may be present; band at 996 cm^{-1} cannot be identified.
	B-natural resin type varnish	NA	NA	Similar to poly(vinyl acetate)

*NA-not analyzed by this technique

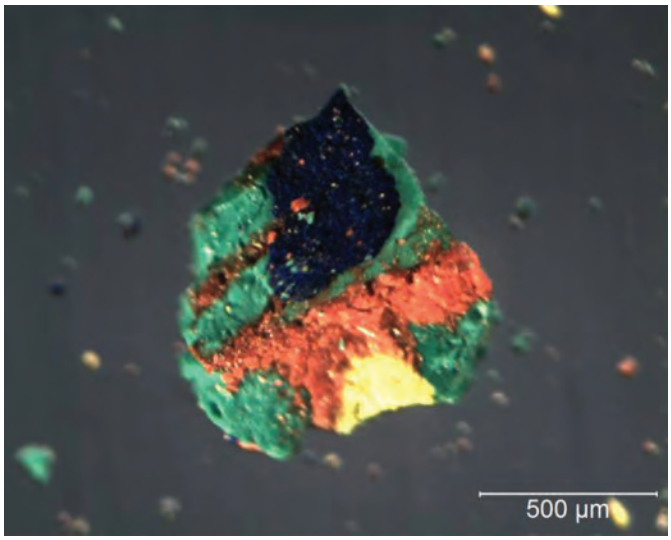

Figure 11. Micrograph of green, red, yellow, blue, and white paint layers cross-section, 75x oblique and transmitted Light. (Courtesy by Joseph Swider, Ph.D. Senior Research Scientist, McCrone Associates, Inc., Westmont, IL)

varnish coating. Thus, the slightly grayed synthetic varnish was retained on the blue paint, and selectively thinned and removed from the white columnar form and the painting's lower half, retrieving the painting's subtle colors shifts and natural luster (fig. 13). Residues of yellowed varnish remaining in low-points in the pastose paint were also removed. As a result, solidity of the columnar form resting on the curved 'earth' became much more tangible, and both the column and 'earth' regained a luminous, ethereal, otherworldly appearance.

Discolored retouching was removed from the old, filled tear repair, and covering small black paint (est.) splatters at lower left. These black splatters were not painted out, as they appear to be original to the painting. These may have also occurred shortly after the painting's completion, having been pressed into and faintly staining the surrounding freshly applied white paint. Blue-black retouching along the painting's turn-over edges was retained, as it was adequately matched to the original paint, and solvent testing indicated little underlying original paint remained intact to be retrieved. The current

Figure 12. Composite digital x-ray radiograph using an x-ray detector with a 130-µm pixel size and 70keV x-ray beam. Francis Picabia, *La Terre est Ronde*, 1951. Composite x-ray image, created by Ken Smith, Ph.D., Center for Art Materials Analysis (CAMA). X-ray radiography carried out at Varian Medical Systems, Lincolnshire, IL. 2014

Figure 13. Detail of lower left corner; before treatment (*top*) and after treatment (*bottom*), after surface cleaning, varnish, and overpaint removal. Francis Picabia, *La Terre est Ronde*, 1951

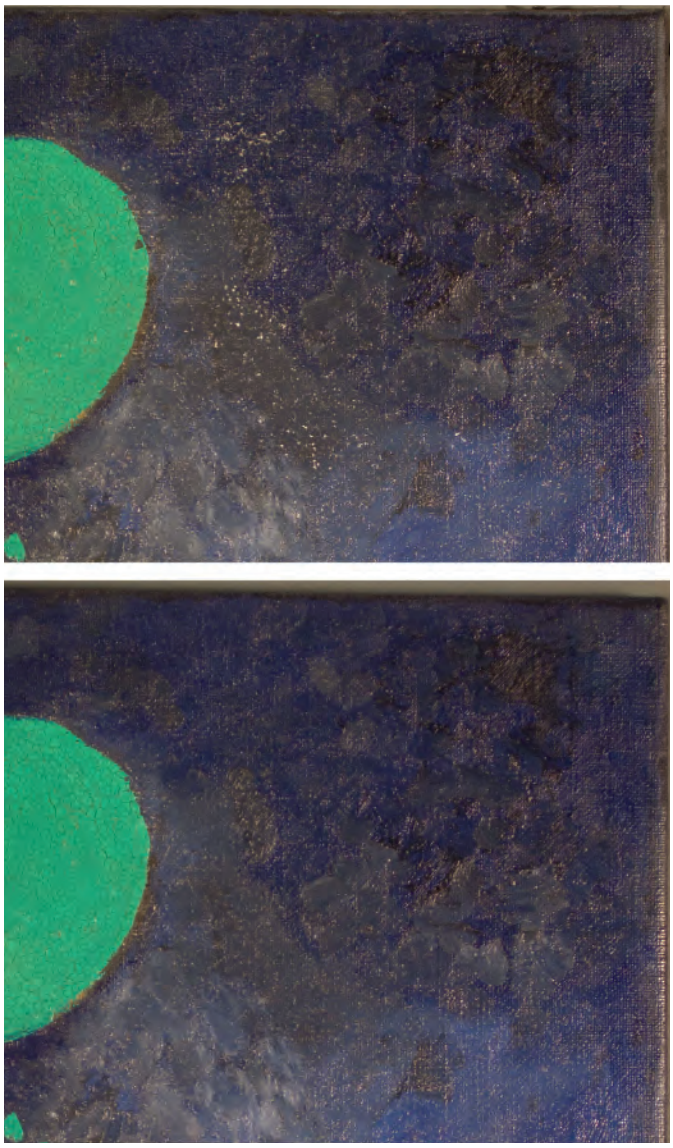

Figure 14. Detail of upper right quadrant before treatment (*top*) and after treatment (*bottom*), after surface cleaning and inpainting of white crystalline efflorescences. Francis Picabia, *La Terre est Ronde*, 1951

stretcher is slightly larger than the original, causing the original tacking margins to be repositioned slightly onto the painting's surface, after the canvas was re-mounted following lining. As a result of this slight size change, the blue-black paint Picabia originally used to cover the tacking margins consequently extended onto the paint surface, and was partially painted over with white paint during the previous restoration. This retouching was retained, as it was acceptably matched to the surrounding original white paint, and the black painted margins did not seem intended to be visible on the painting's surface.

Solvent testing under the microscope, combined with conservation literature research, indicated that the safest course of action was to accept, rather than attempt to remove, the white lead crystals until further conservation research and greater understanding of this phenomenon is achieved. Thus, these crystals were retained and precisely painted over with reversible conservation grade paints[6] to eliminate their visibility, as they were not intended by Picabia (fig. 14). Filling the small losses in the green paint, refilling, and properly texturing the filled tear at lower left and at the small tears where the canvas folds over the lower corners increased the painting's stability and appearance. A fresh, saturating varnish[7] of an appropriate sheen was brush applied selectively to flatter the painting's surface texture, while allowing natural variations in the paint sheen to remain visible. Minimal localized inpainting of filled losses and abrasions visually integrated the painting and allowed it to be fully enjoyed free of distractions. Conservation treatment has retrieved this ethereal image, so it may once again appear as fresh and luminous as Picabia intended, enticing the viewer to fully appreciate the artist's expressive brushstrokes and evocative forms.

4. CONCLUSION

Picabia was known to have used Ripolin enamel paint in some of his later works, thus it was suspected that he may have selectively used this or another untraditional paints in *La Terre est Ronde*. Furthermore, countless small white specks scattered mainly through the dark blue paint at upper right were found to be crystalline efflorescences. Because of these physical anomalies, Picabia's reputation for experimenting with materials, and his common reworking or completely painting over previous compositions, scientific analysis of microscopic paint and varnish samples was carried out.

Information garnered from scientific analysis provided selective material identification of the paint and varnish layers, and assisted with devising the most effective and ethical treatment strategy. Analysis identified the white crystals as lead white, cerussite, and hydrocerussite, with no soap or salt components. The ground layer is composed of lead white, and this may have served partially as the source material for the efflorescence. The presence of lead white precludes the ground layer from being Ripolin, as zinc white was used solely for white Ripolin paint (King et al. 2013, 251). The dark blue paint in the painting's upper half is a synthetic ultramarine (binder inconclusive), with a thin polyvinyl acetate (PVAc) varnish layer.

The FTIR spectra were compared to spectra cited in the article, "Mixed media: an example of Pablo Picasso's combination of nonartist's paints with tube colors from the Menil Collection" (Hanspack-Bernal and Bezur 2013) to determine

the presence of the early 20th century house-paint Ripolin. The spectra from the article are from white and blue paints, similar colors to those in this project. The spectra among the article's samples are similar, even though they are different colors. The Ripolin-based paint spectra have common peaks at approximately 2926, 2855, 1740, 1588, 1416 (very broad peak in all spectra), and 1166 cm^{-1}. Although a few peaks close to these are found in some of the sample spectra, the spectra from the article do not match any of the samples from this project. Furthermore, most of the similar peaks indicate common organic groups such as those in the ~2900 cm^{-1} area for hydrocarbon and ~1740 cm^{-1} for carbonyls.

A cross section of the green paint and underlying paint layers identified the pigments of each layer. The two unusual components of the green paint were particularly interesting: barite, or barium white, which is often used as a colorless paint extender[8]; and hashemite, or barium chromate, which is a bright or "banana" yellow pigment.[9] However, barium chromate may turn slightly greener with light exposure due to the formation of chromic oxide. Barium chromate is not widely used as a pigment by itself, but was most commonly mixed with other pigments to create a lemon yellow paint; thus, its use in the green paint here is quite unusual, and merits further study.

Samples of the synthetic-type varnish indicated it is a polyvinyl acetate (PVAc) coating. Varnish samples originally suspected to be a natural resin-type varnish were found to be methacrylate and PVAc coatings. Yet, it is possible that these samples simply did not contain viable amounts of the visible yellowed varnish residues trapped in the low points of the pastose paint.

Treatment stabilized the painting, preventing additional paint losses, eliminated small yet distracting damages, and regained a sense of luminosity and etherealness to one of Picabia's last paintings. Examination, research, and analysis revealed information about the artist's materials and uncovered some unexpected aspects of this painting, namely the unusual green paint composition, and the artist's overpainting of the angel's head and limbs to create a fully abstracted form. This painting embodies Picabia's artistic interest in creation and destruction, and the angelic symbolism is particularly poignant for use in one of his last paintings. Bridging the earth and heavens, the originally depicted angel of the apocalypse was repainted to represent an other-worldly, unidentifiable column, resting solidly on the earth.

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NOTES

1. As quoted in Felix 1998, "Marcel Jean, who believed it to be Picabia's very last picture, saw 'a form that is undefinable but precise, enveloped in strips of cloth: thus in former times were newly-born babies swaddled and the dead wrapped for burial.' Whether a corpse or a tiny baby signifying new life, perhaps we can see in this indefinable and obscure object art itself, eternally engaged in the cycle of death and resurrection to which the artist subjected it throughout his life."

   And as quoted in Picabia 2002, "Marcel Jean atteste qu'il s'agit du dernier tableau peint par Picabia. 'Le dernier tableau des pientres… Celui que peignit Francis Picabia […] represente une forme indefinissable mais precise, enveloppee de bandettes.' Olga Picabia le confirme (cf. Marsailles 1962) Par la suite, on l'a confandu avec KO auquel fet attribute en second titre La Terre est Ronde, le considerant alors comme l'oeuvre ultime. Camfield [cf. p. 379] a reconnu la source de la forme blanche 'emmailotee,' dans le Septieme Ange de l'Apocalypse de l'Urgell Beatus, manuscript elumine du x siècle figurant en 1927 a l'Exposition d'art roman catalan de Barcelone, vue par Picabia et dont il possedait certainement le catalogue, y ayant puise de nombreux motifs."
2. From a post by a guest blogger on art scene investigation. http://www.artic.edu/blog/2013/05/02/art-scene-investigation-from-can-to-canvas.
3. The Angel of the Seventh Seal of the Apocalypse from the illuminated Urgell Beatus, 10th century Catalan artist, identified by William Camfield as the source for Le Terre est Ronde.
4. Digital x-ray detector with a 130-µm pixel size and 70keV x-ray beam. Composite X-ray image created by Ken Smith, PhD, Center for Art Materials Analysis (CAMA). X-ray radiography carried out at Varian Medical Systems, Lincolnshire, IL.
5. Paraloid B-72 (5% w/v in Xylene).

6. Golden MSA (spirit-based acrylic [MSA] resins) conservation paints.
7. Regalrez ® 1094 (5% w/v) in Stoddard solvent, w/2% w/v Tinuvin ®.
8. Barite. 2017. CAMEO (Conservation and Art Materials Database). Museum of Fine Arts, Boston. Accessed June 21, 2017. http://cameo.mfa.org/wiki/Barite.
9. Barium Chromate. 2017. CAMEO (Conservation and Art Materials Database). Museum of Fine Arts, Boston. Accessed June 21, 2017. http://cameo.mfa.org/wiki/Barium_chromate.

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RUSTIN LEVENSON, OLIVER WATKISS, and VERONICA ROMERO-GIANOLI

The Life of Modern Painted Walls: Ethics, Emergencies, and the Future

ABSTRACT

Recreations of ephemeral and contemporary works have become issues in the conservation field. As outdoor murals become beloved icons in their communities, the works and the walls they are painted on degrade beyond conservation intervention. When this happens, recreations of these works may be planned by the community stakeholders. The recommendations in this article are an effort to put a conservation voice into the planning of recreations or re-paintings of these works.

I. ETHICS

RUSTIN LEVENSON

ArtCareNYC has been asked to consult on the recreation of outdoor murals, most recently *Against Domestic Colonialism* by Arnold Belkin in a park in Hell's Kitchen in New York City. The work, created in 1972, was in very poor state. The urgent, extensive repairs required to save the support wall would result in damaging, then covering the mural. The community determined to recreate the mural, once the wall was repaired. As consultation with the community group and the artists they had hired progressed, it was clear part of ArtCareNYC's job would be to educate the stakeholders on conservation issues.

In 2008, Harriet Irgang Alden, studio director of ArtCareNYC, worked with the Harlem community and with Rescue Public Murals, to repaint Eva Cockcroft's *Homage to Seurat: La Grande Jatte in Harlem*. The work, painted in 1986, had faded markedly. The repainting involved taking cross sections, using original documentation, collaboration with some of the original workers, and using tested materials for the repainting. The steps taken with *Homage to Seurat: La Grande Jatte in Harlem* served as a template for the recommendations that follow.

1. CONSERVATION RECOMMENDATIONS FOR THE RECREATION OF PUBLIC MURALS

1.1 ETHICAL CONSIDERATIONS

Can the work be conserved?

- The degradation of the painting should be beyond conservation intervention.
- There should not be a method of repairing the substrate that will allow the mural to remain in place.

Assessment of the stability of the support and materials for the recreation:

- The support and materials used in the recreations should be stable enough to endure in the location for at least 20 years.

1.2 INITIAL RESEARCH

Gather relevant documents and documentation on materials, techniques, and the original appearance of the mural

- from the artist,
- from the participants in the creation of the mural, and
- historic photographic documentation.

Community involvement

- Define the original and current audience for the mural, the social dynamic, and stake of the community in the recreation.

1.3 LEGAL ISSUES

- Is the work under copyright?
- What are the rights of the artist who created the mural?
- What are the rights of the estate if the artist is no longer alive?
- Can they block recreation?
- Can they dictate involvement?
- Can they disclaim the recreation?
- How should the recreation be signed?

1.4 FINANCIAL ISSUES

- Is the budget realistic?
- Can the ethical obligations be addressed within the budget?

1.5 WRITTEN PLAN

After consideration of the issues, a written plan should be presented to all the stakeholders—the community, the recreators, the original creators, the conservators, and the contractors who will repair the wall.

1.6 FOR THE FUTURE

There should be written and photographic documentation of materials and techniques used in the recreation.

- A list of participants with contact information
- Documentation from original research
- Assurance that the documentation will be available in the future

RECOMMENDED RESOURCES

Conservation Resources: Finding a conservator for stability assessment of the support, material recommendations, AIC: http://www.conservation-us.org.

Working with community groups: Drescher, Tim. 2004. Priorities in Conserving Community Murals. Los Angeles, CA: Getty Conservation Institute. http://hdl.handle.net/10020/gci_pubs/priorities_community_murals.

Legal resources: Lawyers for the Arts: http://www.dwij.org/matrix/vla_list.html.

Materials and techniques for creating murals: The sections on planning, wall selection, wall, or surface preparation, painting, coating, and maintenance outline important considerations for the creation or recreation can also apply to recreating murals. http://www.heritagepreservation.org/RPM/MuralBestPractices/index.html.

Documentation for the future: http://www.artstor.org.

II. EMERGENCIES

OLIVER WATKISS

Of the large numbers of murals in our urban landscapes today, many are substantial in size and usually found to be in prominent places around our cities. Most graffiti artists don't expect their works to last for long. The artists' materials, construction of the walls, and other structures used reflect the locations and opportunities afforded to the majority of graffiti and mural artists. Rail wagons, ship hulls as well as the abandoned buildings that litter much of our urban landscape are often common places for street artists to utilize. These structures are used to form the primary supports, which can vary widely from concrete, brick, and metal surfaces—all of which pose enormous technical challenges to conservators.

Deterioration to the substrate and paint layers in a climate such as Miami's is fast. Although Miami doesn't have the freezing temperatures that can sheer walls through ice expansion, it has copious amounts of salt, heat, constant humidity as well as frequent high winds with lashing rain. (And you all thought South Florida was pleasant.) Sadly, Miami also has a history of public infrastructure neglect, with a preference for destruction and rebuild as opposed to conserve and preserve.

In Miami, there is a well-established and flourishing street art scene, which has become a focus point of pride for Miamians. ArtCareMia has been asked to provide an estimate on the removal of murals and has been a part of conservation teams attempting to establish how to save crumbling works on failing structures. In all cases, conservation treatments are possible but not always welcomed by the street-art community, many of who don't appreciate conservation involvement.

Emergencies are a reality for all disciplines of conservation. Fire and water damage are constant threats exacerbated by the environment through storms such as Andrew, Katrina, and Sandy. "Accidents" resulting in more confined areas of damage like household electrical fires or burst pipes can be equally damaging to the objects in close vicinity.

As a community of conservators, combined, there are untold stories and treatment successes and of course failures in our respected fields in trying to deal with the aftermath of such events. The goals, however, are clear: try and save objects for the future, and conserve the cultural heritage. Money is often a prohibiting factor; nonetheless, as a rule, in an emergency all that can be done is done. As the aftermath of Hurricane Sandy in NYC, clearly illustrates and indeed the banding together of materials and skilled personal to travel to Haiti after the earthquake in 2010 in order to help salvage works of art for the Haitian people in their time of dire need.

Many of the treatments involving smoke-, fire-, and water-damaged paintings that have sustained tears and other structural damages are well documented. There is a strong history of tried and tested as well as ever-evolving methods of treatment. The removal of wall paintings is a well-documented, albeit complicated, process, with early accounts dating as far back as the medieval period. However, it appears that

documentation and research into conservation of street art is lacking with regard to both treatments and materials and of course the ethical implications that they entail.

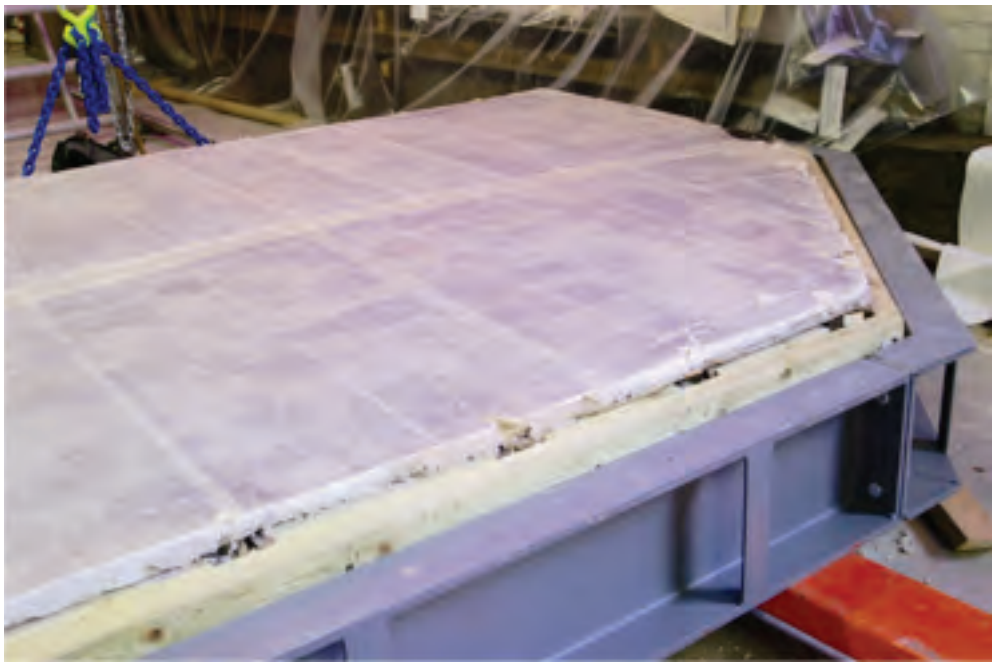
Ever more frequently, murals are extracted from walls and sold, often by amateurs looking to make easy money, leaving in its wake much controversy. The end result of such unsanctioned and amateur extraction is a painting in tatters hiding on the black market or an angry community like that in the coastal town of Folkestone in Kent, England, calling for their mural *Art Buff* by Banksy to be returned from Miami where it was due to be sold (fig. II.1). The ensuing high court battle had resulted in the mural being brought home. This mural was removed without conservators being present or even consulted. Banksy does not authenticate street art and is against people taking work off the street. He has made a few exceptions, however, like in case of *Mobile Lovers*, a mural he painted on the door of a youth-club in Barton Hill, Bristol. He knew they were facing economic difficulties, so he did the piece so that it could be sold to raise money for the club.

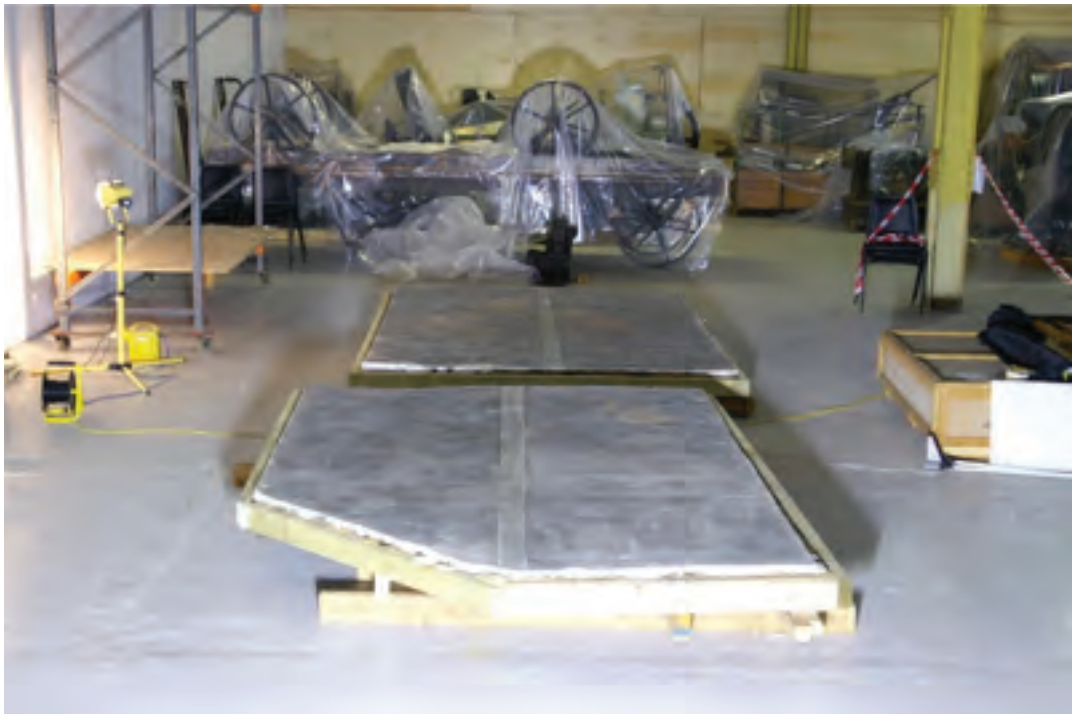
The monetary value of the artists' work is now more than ever finding markets for private collectors and institutions that wish to preserve the past. Household street artists such as Banksy, Basquiat, Herring, Futura 2000, to name but a few, are finding root in popular culture and mainstream art markets. Many more artists worldwide are breaking into this new world of recognition outside of their immediate community.

For centuries, conservators and their predecessors have been removing frescos and murals from one location to another. They have been mounting them onto panels, canvases and other lighter supports as a way of saving these works or allowing them to be transportable so that they reached a wider audience and be resold. The techniques, with varying methods established depending on the type of substrate, paint layer, and condition of the work, are well documented.

Figures II.2 and II.3 show a set of wall paintings the International Fine Art Conservation Studios (IFACS), United Kingdom, worked on in 2008. The murals were cut from a staircase in 1907 in advance of the demolition of a house. The murals were left in an old storage warehouse under the guardianship of the Bristol City Council, where they were forgotten about for many, many years. When IFACS was called in to conserve the artwork, the damages were extensive and the panels were unable to support themselves. The IFACS team worked closely with engineers to construct a steel framework, which allowed for safe treatment, display, and easy handling of the paintings that weighed approximately 1.5 metric tons each (figs. II.2 and II.3).

Figure II.1. Banksy, Art *Buff*. Folkestone, England, 2014. Aerosol paint on concrete (estimated). https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwjnm-j9g_nbAhVBwVkKHXx8CKsQjRx6BAgBEAU&url=https%3A%2F%2Fwww.widewalls.ch%2Fbanksy-art-buff-judge-order%2F&psig=AOvVaw15G2JQam9jAFSDYSzqrHpl&ust=1530367118648748





Figures II.2 and II.3. Antonio Verrio (c. 1636–1707) Century, Bristol, England. Oil on plaster. During conservation treatment2008. Courtesy of International Fine Art Conservation Studios UK

Similar techniques of substrate reinforcement are often applied today to replicate any load-bearing wall or solid structure that needs removing or stabilizing; however, this is a costly treatment and can become more complicated when dealing with street art as the paint layer is applied directly onto the substrate. Often the substrates are thicker, heavier, and can be even less stable and certainly less flexible than lathe and plaster walls of the 16th and 17th century construction.

British graffiti artist, Bambi, was commissioned to produce a mural that was to be sold at a charity auction (fig. II.4). The mural was painted on the outside wall of a disused building in the design district of Miami. The painting was sold, and ArtCareMia was consulted on the possibility of removing the mural for the new owner, who presumably wanted a more intimate setting to view the recent acquisition. To add emergency to the equation, the building was scheduled for demolition.

The mural in the end was lost to the bulldozer, as much of Miami's recent history is sadly lost. Bambi, however, agreed to repaint the mural onto a more transportable support at a far lower cost than the estimate for removing the original mural. This is becoming an ever more frequent tale and is in effect moving street art into a new more accessible collectors' market. Although, this can be seen as a success for the buyer, not all street artists are as accommodating as Bambi was in this instance.

The IFACS has recently extracted one of Banksy's iconic pieces, *The Grim Reaper*, painted onto the hull of a ship. *The Thekla*, a club and music venue, is in the heart of Bristol's dockland, which of course is also Banksy's home turf.

The panel was removed to save it from the damage it would have sustained during the ship's hull renovation. Banksy was contacted, and he expressed his unhappiness with the removal of the mural expressing that he would prefer the mural to be left in place (fig. II.5). The IFACS studio also tried to contact Banksy to gain information about the spray paint used, but he refused to collaborate. The stencil was already in poor condition, however, having been routinely submerged in harbor water and general exposure to the elements.

The 1250 × 1930 mm steel hull structure that was extracted was 55-mm thick and weighed approximately 1800 g. The black background was the result of the application of two thick layers applied onto a primary coat of iron oxide paint. The black paint had already begun to show signs of corrosion even before the stencil was applied.

The panel, once removed, was bolted to an auxiliary frame structure. It was then taken to the IFACS studios for stabilization and cleaning. The DHP family that owned the ship donated the iconic artwork to Bristol City Museum, where it is now on display at the M-Shed, Bristol's dockland museum, which is free to enter.

Figure II.4. Bambi, *Put The Kettle On*. Miami, USA, 2014. Aerosol paint on concrete wall (estimated). Courtesy of ArtCare Conservation

Figure II.5. Banksy, *The Grim Reaper*. Bristol, England, 1980s. Aerosol paint on steel ship hull (THEKLA) (estimated). Courtesy of International Fine Art Conservation Studios UK

The heart of the popular street art scene in Miami is Wynwood, where the majority of the murals are commissioned and great international names of the street art community are pulled in. The Wynwood walls, as they are known, frequently attract large crowds of tourists and locals. Shops, galleries, restaurants, and bars have all sprouted up in remarkably quick succession in response, creating a fluid symbiosis. It has become a thriving and celebrated growing corner of the art world and Miami, with many of the murals taking on an iconic status.

When damage to a mural occurs, either environmental or intentional, tagging, throw-ups or wild styles, depending on the scale, local graffiti artists repaint any losses. If, however, the mural is over two years old, its wall space is invariably recommissioned. This "in-house" treatment is not uncommon and is sadly seen in other areas of conservation, although not as excepted today as it once was. There is an added cost in consulting conservators for a small "tag" that can be easily sprayed over, and that they may even take more time than it took to create an entire 20 × 20 in. mural. Conservators actively discourage other artists from retouching on paintings and other works of art. Is this different, and if so, why?

The recommissioning of wall space is an understandable element to street art where wall space is at a premium. Sadly, however, this leaves an obvious problem: the narrative of the street artist being lost. Photographs of great works will be there for posterity, but the originals are being lost. Should this be the way? Should we accept this as the fate of too many of our cities urban creativity? Many street artists thankfully document their works using both film and photography, creating a performance piece alongside their mural that will likely outlast their principle creation.

Conservators have deep-rooted appreciation for the history of art and the narrative of creativity and expression that each period, style, discipline, and artist builds upon to inspire the next creative. Collectively conservation ensures this narrative.

III. FUTURE

VERONICA ROMERO-GIANOLI

The secretive nature of street art and its countless forms make it hard to define exactly. And whilepeople have different opinions about this public form of expression—"Is it art or is it vandalism?" (fig. III.1)—it has transcended from North Philly and the New York City subway car and earned its place in the contemporary art world. Every day, one is witness to diverse modes of expression, unmatchable ranges of style, and varied levels of experience. From inspirational murals on schools to politically charged messages to spray-can art to stencils, posters, and gallery pieces, this movement is representative of the abundant diversity within the community itself, as well as the audience it reaches. It is alive with intent, spontaneity, and urgency.

Many of these works are orchestrated with permission and are protected, whereas others skirt on vandalism. While some works become representations of the communities in which they exist, others become a part of the environment, exemplifying the conflict between permanence and the temporality in the ever-changing landscape. Each artist develops his or her own fingerprint, style, story, and city influence. Wherever this form of public art is found, the only constant is that it changes the aesthetic of how everything looks and how everyone sees (fig. III.2).

Figure III.1. Toxicomano, *Tales of Graffiti*, 2015-2017, mixed media on concrete, located in Wynwood, Miami, Florida. Courtesy of author

Figure III.2. Lakwena Maciver, *I Remember Paradise*, 2012-2014, mixed media on concrete, located in Wynwood, Miami, Florida. Courtesy of author

Graffiti writing was never meant to be understood by the outside world. Graffiti artists refer to themselves as "writers," and create for the sole purpose of self. Graffiti usually begin with the artist's own name, which develops into a unique signature or "tag" (fig. III.3). Novice artists study these street fonts that soon become the groundwork for the etching of names on school bus windows, black books full of marker colors, and eventually the aerosol can, most likely stolen from the garage. If the artist is fortunate, he or she is passed down knowledge from a mentor, who hands down skills understood only by other writers and not outsiders. For graffiti artists, the spray can provides ultimate freedom of speech at their fingertips. The idea of ownership has no significance at all to most writers, who graffiti tag upon tag because repetition is the only way of existing. Slowly, these tags become recurrent, and it becomes possible to decipher a name or style, showcasing more talent than just scoring a pseudonym (fig. III.4). This is how Futura 2000, Lady Pink, Keith Haring, Basquiat, Kenny Scharf, Barry McGee, Obey, Banksy, and countless others have started.

One would like to report that all street artists are deeply attached to the concept of their artwork only existing for a short amount of time, but this would be inaccurate. Street artists wrestle with issues of public representation, aesthetics, responsibility to their crews and neighborhoods, and their own

Figure III.3. Various Graffiti Artists, *Tags at Atomiko studio*, 2016-2017, mixed media on concrete, located in Wynwood, Miami, Florida. Courtesy of author

Figure III.4. Krave, *MIAMI*, 2014-2015, mixed media on concrete, located in Wynwood, Miami, Florida. Courtesy of author

artistic vision. With so many more commissions, notoriety, and legitimacy, how is the street artist changing?

Gathering information and attempting to communicate with artists as a conservator is also a challenge, and one may find oneself worlds away from impressing any street artist one's profession as a conservator. Often one may find that street artists do not even speak the same language, as this community has its own slang and terminology (fig. III.5).

Most artists do not refer to themselves as graffiti artists; they may label themselves as writers. They may not consider themselves writers, but as street artists. They may not identify as street artists, but more a muralists. They may cringe at being labeled in general, and prefer to be called artists. The terminology in the street art culture is extensive, and it is important to ask politely if one identifies with any label in particular. Following conversations with many artists is also challenging. While their slang is extensive and ever growing, following are some terms that may help navigate a conversation.

black book: a graffiti artist's sketchbook

tag: a stylized signature usually done in color; also a verb meaning to sign

throw up: a more complex tag with more time invested; bubble shapes often form the letters

wild style: graffiti with text so stylized as to be difficult to read

hand style: handwriting particular to a graffiti artist with a good flow of letters

one-liner: a tag written in one constant motion

paste-up: a stencil or paper fixed to a wall using wheat paste

piece: short for masterpiece

Figure III.5. Daks and June, FS Crew, *Tribute to Crude Oiler*, 2014–2016, mixed media on concrete, located in Wynwood, Miami, Florida. Courtesy of author

soak up!: inspirational pieces

bite: stealing another artists style or ideas

stainer: a marker used to tag

rusto: rust-oleum spray paint

cannon: a spray paint can

fat cap: a nozzle used for wide coverage

racking: shoplifting paint

dropsy: a bribe

paint eater: an unprimed surface such as wood or concrete

slap: shipping company labels with a writers tag or character on it

back jump: quickly executed throw up, usually on moving vehicles,e.g. trains, buses

beef: grudges against other writers or crews

bomb: to paint many surfaces in one area

diss: tag over another's graffiti

toying: disrespecting someone else's graffiti by means of going over it, usually by someone with less skills or no reputation

cheap fame: tagging near the work of another artist who has notoriety

run: the length of time graffiti remains up before being covered or removed

gallery: locations where artwork is likely to stay untouched for some time

heaven spot: pieces that are painted in hard-to-reach spaces that often pose dangerous challenges to execute

buff: to remove graffiti with chemicals or paint over it with a flat color

massacre: covering up an accumulation of tags and leaving a blank space

landmark: the spot of a deceased writer's work

king: a writer respected among other writers

hat: stands for honor among thieves; an artist considered trustworthy

How do conservators identify with a culture so rooted in the ephemeral nature of their work, when one of their main purposes is to preserve and protect? How does one begin a conversation with artists about the vision of what the street art genre can and should do? Are there any ethics or moral code at all for these artists? Who owns this visual space? Who assigns significance?

Ethics vary from artist to artist, but there are general ground rules within the community that are passed down to younger generations through a master/teacher format.

Respect your elders: While there are "beefs" both personal and between crews and "disses," "cheap fame," and "toying" from rookie artists, the consensus is to respect your elders. Street art is public art, and it is always subject to being covered, either by another artist or "buffed" by an outsider, but try not to "diss" your elders.

Your crew is your family: Your crew is your status symbol; they are individuals that have great mutual respect and trust for each other. The benefits for having a crew are for protection, the pooling of ideas and supplies, and an identity. The dynamics of a crew often fill the voids of a failed education system or a broken family with camaraderie, trust, and the sharing of passions and ideas.

Don't put up a piece that is anything less than: Street artists learn to embrace the fleeting quality of their artwork, but you must not go over another artist's work unless you know you can create something that absolutely deserves to be on public view, and by this, artists mean "skill." Graffiti artists aim for visibility and try to impress others within their own community. Mastering "can" control is difficult and takes a lot of commitment to learn how to use. Do not take a "spot" if you know you are not worthy of it. Don't be a "toy" (an inexperienced writer).

Don't get caught: For many countries around the world, graffiti and much of street art is an illegal act, consequentially with hefty fines and even jail time.

Is the commission of a piece or the artwork on a legal wall still considered graffiti? This is a contested issue among artists. Some do not personally consider legal murals pieces of graffiti, but you cannot deny that legal yards are places where graffiti exists. If a writer thinks its graffiti, then its graffiti, and all writers would still create aerosol art even if it was legal. Any way that you ask the question, all artists would rather have a painted wall then look at bare cement or brick (fig. III.6).

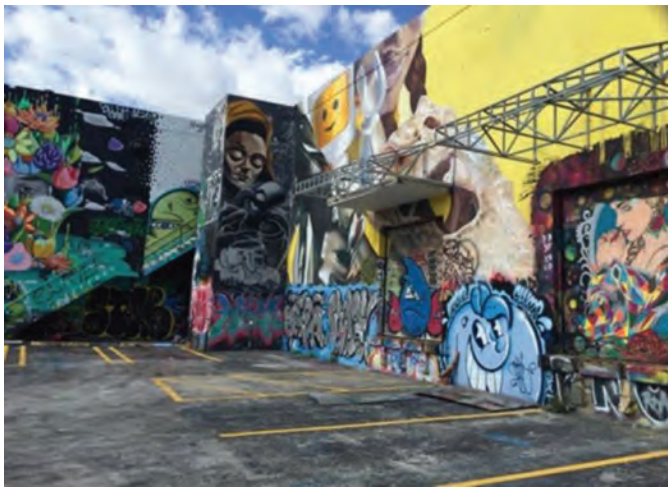


Figure III.6. Various Graffiti Artists, 2015, mixed media on concrete, located in Wynwood, Miami, Florida. Courtesy of author

Figure III.7. RIME, *Vandal Eyes*, 2012, acrylic aerosol on brick, located in Detroit, Michigan. Image source: Tumblr.com

So how do these artists feel about the recent gallery price tags, the relocation of certain artworks into a museumsetting, or the lifting of their designs for advertisement orprofit—the ownership of an artwork that was made to be freefor all? Is there any ownership of ideas or images? Are opportunists bending the rules knowing that this community prefers their recognition as outsiders?

As the popularity of the street art culture grows, so do the lawsuits. It seems now that on a daily basis, one can read of lawsuits between an artist(s) and corporation, where a design has lifted and printed for profit. While one would think that these are clear-cut cases of copyright infringement, one can also refute that most graffiti is an act of vandalism and therefore should not be protected by the law, or claim fair use under Freedom of Panorama. Often "defendants must dig deep for grounds that rely on a far too stringent fact pleading standard, or on misstatements of law." (Rimes, Joseph Tierney, Hypebeast)

- Designer Moschino used artist Joseph Tierney, Rimes, tag and signature character Vandal Eyes to create runway fashion that was most notably worn by Katy Perry at the Metropolitan Museum of Art Costume Institute Gala (fig. III.7).
- American Eagle Outfitters used David Anasagasti, Ahol or Ahol Sniffs Glue, Ocean Glass murals for advertising on its website, social media pages, targeted marketing, and billboard in downtown New York City and store displays from Tokyo to Panama (fig. III.8).
- Director Terry Gilliam was sued over the use of a street art mural shown in his movie The Zero Theorem.
- Starbucks was recently sued for lifting designs for their single-use plastic cups from artist Maya Hayuk (fig. III.9).

Figure III.8. Ahol Sniffs Glue, *Ocean Glass,* 2013, acrylic aerosol on concrete, located in Wynwood, Miami, Florida. Courtesy of author

Figure III.9. Maya Hayuk, Women *On The Wálls*, 2012-2017, acrylic aerosol on concrete, located in Wynwood Walls, Miami, Florida. Courtesy of Martha Cooper @mayaHayukart

Cases are plentiful, and artists accuse legal teams of "bullying, acting unethically and intentionally misconstruing the law" (Rimes, Hypebeast). In talking with artists, the majority just ask that to be contacted. Graffiti artists admit to being allusive but often ask that they be reached for approval, permission, or offered compensation for their creative ideas.

Museums and galleries are not excluded from taking ownership of images and actual street art intended to be on public view. While many artists have successfully made transitions from the street to gallery, many have no desire or intensions of being displayed privately (fig. III.10).

- Banksy's works on cinder blocks and stonewalls were removed from their original locations in Israel, England, Los Angeles, and San Francisco to be sold at Art Basel Miami Beach (Miami Herald, 2012).

Figure III.10. Banksy, *Exit Through The Gift Shop*, mixed media on canvas. Image source: news.bbc.co.uk

- Barry McGee's or TWIST public work on ceramic panel was ripped off a wall from San Francisco's Judah & Sunset Muni Metro stop (CNN). When faced with the physical demise and sale to a collector of an iconic mural in Clarion Alley, San Francisco, Barry McGee himself took a sander to his own work, claiming "the preempting of a robbery" and passing out souvenirs of mural dust in plastic bags (Street Art San Francisco).
- BLU (secretive artist) destroyed 20 years' worth ofhis own work in Bologna, Italy, rolling over them withgray paint as an act of protest against the exhibition, "Street Art: Banksy & Co.," which took place atBologna's historic Palazzo Pepoli. The show was curated by the city's Academy of Fine Arts in an attempt to "[salvage street art] from demolition and [preserve it] from the injuries of time," (Genus Bononiae, president of Academy of Fine Arts and Banca Imi) (fig. III.11).

Frequently, art theft is depicted as something only fated for paintings by fine artists such as Vincent van Gogh, Pablo Picasso, or Edvard Munch, but on a consistent basis one is witness to endless examples in urban art as it rises in popularity. Just as any other artist, these individuals struggle with method, content, and power, but more often one sees these artists faced with the physical and visual demise of their creations outside of the pristine environments of a gallery or museum.

The street art community is full of complexity and diversity and hopefully conservators could become the catalyst for compelling dialogues between artists and professionals, honoring the elevated forms of graffiti that exist today and possibly aiding in the preservation of the visual culture that is left behind (fig. III.12).

Figure III.11. Blu, Painting over a mural by Blu, 2016, mixed media on concrete, located in Bologna, Italy. Courtesy of Michele Lapini via Blu's website

Figure III.12. Banksy, Workers unpack sections of Banksy's graffiti works, mixed media on concrete, 2014, London, England. Courtesy of John Stillwell

ADDITIONAL SOURCES CONSULTED

Marite Iglesias, Director of Arts Goldman Properties and Wynwood Walls

Artists: Tao Rey, Johnny Robles, Jose Parla, Adam Vargas (Atomik), Gustavo Oviedo (131 Pest), Andrew 2Alas, Hox, Crome, Krave, Abstrk, Pucho, Ynot, Edge, Quake, Cale

Books: *Subway Art*; *Spray Can Art*; *The Terrible Nasty T-Kid*; *The Art of Getting Over*; *The Faith of Graffiti*; *Graffiti Kings*; *Dondi White*; *Fuzz One*; *San Francisco Street Art*; and *Getting Up*

Movies: *Bomb It*; *Style Wars*; *Infamy*; *Exit through the Gift Shop*; *Piece by Piece*; *Wild Style*

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HILDA ABREU UTERMOHLEN and VIVIANA DOMÍNGUEZ

Reconciling the Past through the Conservation of the Fresco Mural Painting: *Haitian Massacre, 1937*, by Dominican Artists José Ramírez Conde and Roberto Flores

ABSTRACT

Work is in progress of the conservation of the mural Haitian Massacre 1937 (1974), by José Ramírez Conde and Roberto Flores, painted in a home in Santo Domingo, Dominican Republic. During the house demolition in 2013, the mural wall was cut away and moved across the street, and it sits there in poor condition and at risk of deterioration. A project is underway for its move, installation, and conservation, funded by the Ambassadors Fund for Cultural Preservation of the U.S. Bureau of Educational and Cultural Affairs, with the participation of a Dominican, Haitian, and U.S. conservation team. The authors discuss the emergency rescue, condition, upcoming move and installation at the Museo Memorial de la Resistencia Dominicana, and conservation concerns.

1. INTRODUCTION

Murals are executed on a variety of built surfaces. When such structures are to be torn down to give way to new constructions, these artworks may be at risk of being destroyed along with them, due to a lack of awareness of their value, and financial and time constrains of the developers, owners, and custodians involved. The fresco mural, *Haitian Massacre, 1937*, painted in 1974 by Dominican artists José Ramírez Conde and Roberto Flores would have almost run into the same luck had it not been for a neighbor, Cristian Martínez Villanueva, who conducted an emergency rescue of the mural wall on behalf of the Memorial Museum of the Dominican Resistance in Santo Domingo. Martínez Villanueva placed it in an outdoor location, and it sits there until it is moved and installed at the museum.

From the initial assessment by Utermohlen in 2014, it was evident the mural had sustained extensive mechanical damage because of its retrieval from the house and that it needed major conservation treatment to prevent further deterioration and damage. Utermohlen realized that a larger project, with the aid of special funding, would be needed than was initially foreseen. In the spirit of fruitful bilateral collaboration and understanding between the Dominican Republic and Haiti, conservators Hilda Abreu Utermohlen and Viviana Domínguez put together a team of experts from both nations to work on the treatment of the mural alongside a team of architects and engineers who would work on the transportation and installation of the mural. The proposal, *Conservation of the 20th-Century Fresco: "Haitian Massacre, 1937," by Dominican artists José Ramírez Conde and Roberto Flores*, was prepared, and in 2015 the museum was awarded funding from the Ambassadors Fund for Cultural Preservation under the aegis of U.S. Bureau of Educational and Cultural Affairs. In this article, the authors present the project (still in its early stages), challenges, current status, and reflections on the next steps.

2. THE MURAL

The artists painted the fresco in the living room of a private home in a seaside suburb of Santo Domingo, Dominican Republic, on a concrete cinderblock wall reinforced with rebars (fig. 1). The subject matter represents a well-known episode of the modern Dominican and Haitian history: the government-sponsored assassination in 1937 of a few thousands of Haitian civilians who lived in the northwestern Dominican borderlands near Haiti, during the dictatorial regime of Rafael Trujillo, which lasted from 1930 until his assassination in 1961. Working under direct orders of Trujillo, Dominican troops hunted and killed within a few days an undetermined number of defenseless Haitian men, women, and children, reportedly, to stop Haitians from stealing cattle from Dominican farmers. In addition, historians attribute other contributing factors to this massacre, such as a recent border agreement between both countries, as well as nationalistic and racial motives promoted by Trujillo. With a death toll estimated between 1000 and 12,000–17,000 (Vega 2012; Museo Memorial de la Resistencia Dominicana 2011), this event—known today as the *Haitian Massacre, Parsley Massacre, or*

Figure 1. José Ramírez Conde and Roberto Flores, *Haitian Massacre, 1937*, 1974, fresco mural on concrete cinderblock wall, h 112-1/16 in. × a 137–13/16" (h 285.00 × a 350.00 cm). Credit: Cristian Martínez Villanueva.

Haitian Genocide—caused the outrage of the international community, and, according to *Wikipedia*, its effects still linger in the Dominican-Haitian relations. In the mural scene, the artists represent a group of Dominican soldiers taking Haitian civilians prisoners, with the composition framed by a painted chain.

This rare representation of the massacre is one of the few known Dominican paintings—or photographs that depicts the *Haitian genocide of 1937* (De los Santos 2014, pers. comm.), which confers to it a unique historical and educational value. It is a strong commentary in denunciation of this heinous act. This was in the spirit of the issues addressed by the artists, who began their careers in the sixties during a period of political and social changes that took place after the dictator's assassination in 1961 (De los Santos 2005). It has artistic value in its own right, both as an example of the artists' oeuvre, as well as for its execution as a fresco. The technique was practiced by only a handful of artists for a brief period during the sixties and seventies, representing allegoric and social subjects, many of which were painted by Ramírez Conde and Flores (Goris 2011).

2.1 Rescue of the Mural

As this house was being demolished in 2013, Cristian Martínez Villanueva, a neighbor from across the street phoned Luisa De Peña Díaz, Director of the Museo Memorial de la Resistencia Dominicana—who was away on travel—and asked her whether the museum would be interested in this work. Without having seen the wall, she instructed him to salvage the mural on behalf of the museum, as it had value to the museum both artistically (for its potential as a powerful interpretive tool of the history of the massacre) and socially (for the teaching of human rights) (De Peña Díaz 2014). Immediately, Martínez Villanueva asked the engineer in charge of the demolition for permission to retrieve the wall before the house was torn down, and he was granted a day to do it. An architect, artist and museum director himself, Martínez Villanueva directed the operation through the night, in which the wall was cut away from the house from all sides, both manually and with electric cutting tools, and a makeshift protective frame of steel tubes and angles was soldered around the mural. The wall was then transported with a lift across the street and placed in his front yard by the driveway (fig. 2). The steel frame was left in place, with additional angles added as support, and the mural was covered with a tarp (Martínez Villanueva 2014). The mural is still sitting freestanding in this outdoor location, awaiting transportation and installation at the museum (fig. 3).

2.2 The Permanent Installation Site

The permanent installation site would be the Memorial Museum of the Dominican Resistance. Its mission is "to promote the historic significance and citizen's conscience of the struggle of various generations of Dominicans during the dictatorship of Rafael Trujillo, its antecedents and consequences,

Figure 2. Prior to this project, in 2013 the mural wall was cut away from the rest of the house and moved across the street with a lift, in an emergency rescue operation to save it from demolition. Courtesy of Cristian Martínez Villanueva

Figure 3. After this emergency move, the mural was placed in the front yard of a private residence and covered with a plastic tarp, awaiting transportation and installation at the museum.

thus divulging this knowledge to society." It is a memorial to the people who died in the name of democracy and a place to raise awareness among the new generations of the value of life and human rights (fig. 4).

The museum opened to the public in 2011 in a remodeled two-story building in the Colonial City in Santo Domingo. Founded in 1498 by Bartholomew Columbus, on the south coast of the island of Hispaniola, Santo Domingo is the oldest permanent European settlement of the Americas. In its early

Figure 4. The mural will be moved and installed at the Memorial Museum of the Dominican Resistance, Santo Domingo, Dominican Republic. Courtesy of Teresa Raulina Capellán

years, it was the gateway to the Spanish territories of the region. Many of the colonial buildings are still present, as part of the grid layout of the city. Today, the Colonial City it is the main tourist attraction of Santo Domingo. It was declared a UNESCO World Heritage Site (UNESCO website), and as such, it is protected by various legislations. As the authors later realized, this would have an incidence on the project, since any possible building alteration related to the mural installation would require of special permits.

3. THE PROJECT

3.1 Background

A year after the rescue of the mural, Utermohlen was consulted to examine it and draft a plan for its relocation and conservation. The mural was in very poor condition, due to physical damage suffered, and its outdoor location exposed it to risks from various agents that would accelerate its damage and deterioration (fig. 5).

Figure 5. When the mural was examined for the first time by Utermohlen in May 2014, the damage incurred during the 2013 extraction of the wall was evident in the numerous losses of mortar throughout the surface. Courtesy of Hilda Abreu Utermohlen

3.2 Objective

The objective of the project is the relocation of the mural to the museum, its installation and conservation. The aim is the preservation of the fresco to put it in public view in a museum setting, where it would be appreciated by the public, in all the values associated with it, in order to prevent further damage and deterioration beyond repair.

In October 2014, the U.S. Embassy in Santo Domingo invited the museum community to submit projects for the program: *Ambassadors' Fund for Cultural Preservation 2015 (AFCP)*, a program of the cultural section of the Office of Public Affairs of the U.S. Embassy in coordination with the Office of Educational and Cultural Affairs of the State Department. Through it, the U.S. State Department helps eligible countries throughout the world to preserve their cultural heritage. This program takes into account the importance of the heritage, the urgency of its conservation, and the impact of the support of the United States to the project (Bureau of Educational and Cultural Affairs 2016). With little over a month's time, Utermohlen collaborated with the museum in preparing a proposal. Since there was no mural conservator in the country specialized in frescoes, an international mural conservator needed to be involved, and to that effect, Utermohlen contacted Domínguez early on. Because of the tight deadline, it was not possible for her to travel to examine it firsthand. Therefore, the authors submitted the information for the grant proposal on the basis of Utermohlen's preliminary condition report and agreed that the complete examination by a mural conservator would have to be left for once the project began.

In collaboration with the move, engineer Domingo Toribio, and the museum building manager, Teresa Raulina Capellán, Utermohlen evaluated possible routes of access to the museum building, as well as installation sites within the museum. After careful consideration, a sidewall in the lobby was selected, by the front entrance.

3.3 Project Description

By September 2015, the museum was informed of the award, and the project began in January of 2016. It was structured in six phases as follows:

Phase 1: Further condition examination with international mural conservator. Design moving frame and installation base. Move plan.
Phase 2: Prepare moving frame, and protection of the mural for transportation. Build mural base, and preparation of the museum space for receiving the mural.
Phase 3: Transportation. Removal of steel frame. Installation.
Phase 4: Conservation treatment (consolidation, cleaning, filling, and inpainting).
Phase 5: Replace, reinstall, and repair building features.
Phase 6: Final reports and maintenance recommendations.

The key participants of the project are:

Museum director Luisa De Peña Díaz
Project conservator Hilda Abreu de Utermohlen
Leading mural conservator Viviana Dominguez
Two technicians, from the Dominican Republic and Haiti, respectively
Mural installation director Iván Fernández Sterk, with Einstein Fernández
Move operation director Domingo Toribio Mena
Museum building manager Teresa Raulina Capellán
Participation of museum staff

3.4 Domínguez's Initial Involvement in the Project

Before coming to work on this project, Domínguez worked for the Smithsonian Institution Haitian Cultural Recovery Project from 2010 to 2011 after the earthquake in Port-au-Prince, Haiti, as the lead mural and paintings conservator. Among the projects she was assigned were the removal of three murals from the Saint Trinité Episcopal Cathedral and training local artists to assist on the recovery of the murals and easel paintings.

Domínguez was thrilled when Utermohlen invited her to work on the fresco mural project. They had worked together in 2008 on the conservation survey of 23 murals in the Dominican Republic. With this fresco conservation project, they saw a great opportunity for bi-national collaboration between the Dominican Republic and Haiti by bringing in Joseph Fils Racine, who had worked with Domínguez at the Cathedral in Haiti and had the training experience necessary to work as a technician on the Conde-Flores mural. Likewise, the authors plan to train a local technician to work along in the team.

3.5 Before-treatment Condition Report

In January 2016, Domínguez travelled to Santo Domingo to work with Utermohlen on the examination of the mural, to discuss the logistics for its move with the team and adjust the initial treatment proposal (fig. 6).

Even after two years of being outdoors and covered with worn plastic tarps, the condition of the mortar was good, and it was firmly attached to the wall, except for the places where it had suffered mechanical damage (fig. 7). Nevertheless, there are clear signs of deterioration such as mold growth, corrosion, and dirt exist. In its outdoor location, only 100 meters away from the sea, the wall is exposed to tropical humidity and rains.

Figure 6. In January 2016 Hilda Abreu Utermohlen (left) and Viviana Dominguez (right) documenting the condition of the mural in its temporary outdoor location in Santo Domingo, in preparation for its future move to the Memorial Museum of the Dominican Resistance. Courtesy of Teresa Raulina Capellán

Figure 7. Viviana Domínguez documenting the numerous losses of mortar, associated with the places where the mural had suffered mechanical damage. Courtesy of Hilda Abreu Utermohlen

Also, the incoming sea spray carries moisture and inorganic salts, which are aiding corrosion of the structural rebars of the wall and the metal frame (fig. 8).

The wall is very large: h 285 cm × w 350 cm × 23 cm thick and weights approximately 5 tons. It is constructed with cinder blocks, with rebars inserted in the hollow areas and filled with Portland cement and sand It is a standard construction in the country (fig. 9). It stands braced by rectangular steel and angles and is being supported by an easel-like steel structure. The metal is rapidly corroding. This is unsafe for the piece and not suitable for moving it to the museum. The reverse of the wall is plastered and painted with peach-colored latex house paint. It is quite dirty and exhibits large areas with biological growth (fig. 10). On the mural side, the wall is finished with a cement, lime, and coarse sand mixture (also called *arricio*). The fresco mortar or *intonaco* (lime and a finer sand grade) is unevenly applied. It is 1 in. thick on one end and quite thinner on the other end.

The pigments are natural earths (or ferric oxides) such as yellow ocher, raw sienna, and burnt sienna, or possibly a red oxide (fig. 11).

Most of the damage on the mortar is mechanical. There are noticeable large losses of the wall and mortar and many surface scratches that may have occurred during the demolition of the house and removal of the wall. The authors also observed some old repairs, such as paraffin fills, which suggest that some of the damages may have occurred prior to the demolition of the house. In addition, the mortar is partially detached along the lower edges and mold growth is located mainly on the lower left corner (fig. 12). As discovered by Domínguez, the mechanical damages notwithstanding, the mortar itself is sound.

Dominguez performed a few tests in preparation for the treatment phase. On the few areas that needed consolidation, they applied CaLoSiL® E25. For the fills, she tested a

Figure 8. The left edge shows signs of damage and deterioration, such as: detachment of the mortar, mold growth, dirt, and corrosion of the auxiliary steel frame, as documented by Viviana Domínguez. Courtesy of Hilda Abreu Utermohlen

Figure 9. Side view of the mural wall after it was cut away from the rest of the house, showing its fabrication technique. The wall is constructed with cinder blocks and rebars inserted in the hollow areas and filled with Portland cement and sand. Courtesy of Viviana Dominguez

Figure 10. The reverse of the wall is plastered and painted with a peach-colored latex house paint. It is quite dirty and exhibits large areas with biological growth. Courtesy of Hilda Abreu Utermohlen

Figure 11. Overall view of the mural in its temporary outdoor location, during the condition examination performed by Dominguez and Utermohlen in January 2016. Courtesy of Teresa Raulina Capellán

Figure 12. Detail, lower left, showing detachment of the mortar and mold growth. Courtesy of Hilda Abreu Utermohlen

lime-based mixture with different grades of sand to match the original texture and color. As additional documentation, and as an aid for the treatment phase, the authors traced the outlines of the design, to have a life-size template of the image (fig. 13). On the basis of this condition examination, the treatment plan was adjusted accordingly.

4. DISCUSSION

The large dimensions and weight of the mural presented challenges for the move and installation operation, which required careful planning and coordination from the move and conservation teams, including taking into consideration that the mural wall was taller than the door opening and that the foundation at the museum installation site might not be strong enough to support the weight of the mural.

Logistically, the move entailed travelling by narrow colonial streets, and entering the mural into the museum through the small doorway.

For allowing access of the mural through the doorway, the team of conservators and engineers proposed that the entrance height be widened by removing two-to-three of the entrance steps and removing the adjacent wood and glass doors. They also suggested excavating the ground (which is a modern fill) to build a strong foundation to support the mural and then installing it by affixing it to the ceiling and the base. Initially, the museum director did not approve of this proposal, since they had recently renovated the building and were not ready to undertake more construction work. Also, because the building was located in the Colonial City, they would require permits for any changes, even temporary, on the building. The museum director requested the conservators to evaluate alternative options to excavating the building, which would reduce the weight and dimensions of the mural, in order to facilitate its access and to lower the impact on the building. The authors considered some of the following options:

1. *To perform a stacco*. In other words, to detach the fine mortar or *arricio* from the wall and transfer it to an alternative support that would, in turn, be attached to the wall in the museum.

Figure 13. Teresa Raulina Capellán tracing the outlines of the composition, to have a life-size template of the image as additional documentation, and as an aid for the treatment phase. Courtesy of Hilda Abreu Utermohlen

The method presents too many risks to the fresco since it entails making various cuts on the surface, which may cause considerable amount of losses and would require more conservation. Also, the mortar is well adhered to the wall, which provides adequate support. Given these risks, this option was ruled out.

2. *To reduce the weight by thinning the thickness of the wall.* The architects' and engineers' opinion was that this would greatly weaken the wall supporting the fresco, and would increase the risk of suffering potential structural damage during transportation. Also, the weight reduction that would be obtained would neither be significant enough to alter the move and installation plan and not would it solve the problem of reducing the overall dimensions. So, this option was also ruled out.
3. *To reduce the size of the mural.* To do so, the safest way would be to cut through the mortar joints, removing two rows of cinder blocks, equivalent to 37 cm. Once the mural was installed, the parts would be reattached and the seams concealed. Because of the alteration of the integrity of the mural, the conservators did not recommend this option either.

5. CURRENT STATUS

After a few months of ongoing discussions, through Utermohlen's persistence and the engineers' Fernández and Toribio advise, in May the museum director approved to look into the possibility of keeping the mural in one piece and to allow instead widening the building entrance, albeit temporarily (fig. 14).

Since then, Utermohlen and De Peña Díaz have already met with the director of the Office of Heritage and Historic Center of City Hall, who approved the intervention of the front steps. Still pending at the time of the presentation of this

Figure 14. Conservators and engineers in a brainstorming session discussing options for moving and installing the mural, which would optimally preserve both the mural and the historic house where the museum is located. Seen here from left to right: Carlos Luis Pinedo (architect, advisor), Domingo Toribio (operations engineer and Move director), Viviana Domínguez (Lead mural conservator), Iván Fernández (structural engineer and Intallation director), and Hilda Abreu Utermohlen (project conservator). Courtesy of Teresa Raulina Capellán

article was the approval by the director of Monumental Heritage of the Ministry of Culture. This would determine the course of action to take with regard to moving the wall into the building.

6. CONCLUSIONS

This project entails a series of activities that require the participation of professionals from various areas of expertise. In this case, there are two cultural properties to consider: the mural and the museum building, both having their own sets of values attributed to them. Both are under the stewardship of the museum, which is responsible for preserving the unique historic characteristics of the building and the collections housed in it.

The execution of this project poses challenges for the preservation of both the building and the mural, according to best practices in conservation, since its implementation may result in a higher-than-desired intervention of either the mural or the building. Even though not all team members came with the same experience at working with cultural property, they all came to an understanding of what the main issues were and what they wanted to achieve.

The authors believe that through a constant dialog and teamwork, they can reach optimal solutions for the successful completion of the project. Moreover, the integration of a multinational conservation team will contribute to the knowledge of mural conservation, as well as provide for an experience that will contribute to building bridges of understanding among its participants.

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The Resurrection of *The Angel*

EXTENDED ABSTRACT

Conservation science is a powerful tool that can change and sometimes even reverse the way we experience a historical artwork. This was the case with a painted high-relief at St. Mark's Anglican Church in Barriefield, Ontario—a piece better known to its congregation as *The Angel*. Recent conservation efforts guided by research, rigorous methodology, and a strong sense of ethics have brought to light important and unexpected aspects of this artwork. These discoveries ultimately led to the successful conservation and revelation of *The Angel*'s glorious past.

The Angel mysteriously appeared on the north chancel wall of St. Mark's sometime after 1897. This unique high-relief occupies the north chancel wall at the front of the church and is distinguished by its large-scale format-measuring 5 × 4 m. Its manufacturing technique consists of painted cast plaster and its singular iconography represents an angel and three cherubs. Though the relief bears no artist signatures or marks, literary evidence indicates that the piece was restored in 1951 by a famous Canadian painter, André Biéler (1896–1989). Biéler was an art professor at Queen's University from 1936 to 1964 and was also the founding director of the Agnes Etherington Art Centre (1957).

The artwork was analyzed by polarized light microscopy (PLM), Fourier-transform infrared spectroscopy using attenuated total reflectance (ATR-FTIR), and infrared and ultraviolet photography. Analyses confirmed the nature of the substrate, identified the binder used in the paint sub-layers, and most importantly, revealed the complete paint stratigraphy, which clearly indicated three distinct painting campaigns. Further solubility tests for overpaint removal confirmed the analytical results and revealed unexpected details.

On the basis of analytical results, it was concluded that what was thought to have been painted by André Biéler had in fact been completely overpainted by the third and last restoration campaign. Before treatment, this outermost paint layer, which was very roughly executed, was all that was visible to the church and community members. In collaboration with Mr. Patterson, Father Haynes, Mr. Du Prey, and many parishioners of St. Mark's Church, the conservation treatment successfully brought the artwork back to the second painting campaign, which is much closer to the original artistic intent.

Figure 1. Before (a) and after treatment (b) images of *The Angel*. ©CSMO 2014

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Observations from a Condition Survey of Walt Disney Animation Cels[1]

ABSTRACT

A study of 5700 animation cels between 1937 and 1989 from the Walt Disney Animation Research Library revealed relationships between their condition, production date, painting technique, and housing. Observations of the paint texture, gloss, brittleness, and opacity in the condition survey using incident, raking, and transmitted white light and UV-induced luminescence revealed periods of paint composition. These observations were consistent with paint formulation notebooks at the Disney Ink & Paint Department and confirmed by chemical analysis. Of the 5% of cels surveyed that exhibited paint defects, the severity of cracks, detachment and loss were related to paint composition. These findings inform research into storage environment and conservation treatments for the collection.

1. BACKGROUND

Until the advent of computer-generated imagery toward the end of the 20th century, hand-painted cel animation was the usual method for creating animated movies. A typical cel consists of a transparent plastic sheet made from cellulose nitrate, cellulose acetate, or polyester with inked outlines on the front (fig. 1), and paints applied within the outlines on the verso (fig. 2). The illusion of movement was created by photographing onto motion picture film sequences of animation cels that displayed incremental differences in image position. On average, 24 separate shots provided one second of movie film, which means that roughly half a million finished cels were needed for 80 minutes of film (Thomas and Johnston 1981). Having served their initial purpose, animation studios tended to discard their cels immediately after production, to sell them in limited quantities or to wash and reuse the plastic sheets (Witkowski 1994). Since the mid-80s, animation cels are no longer seen as simple functional items created solely for the purpose of making a movie, but rather as works of art in their own right (Mikulak 1995), serving as historical, technological, and cultural documents of their time. Accordingly, archivists and conservators are faced with questions of preservation, conservation, and access.

Unlike other studios, the Walt Disney Studios developed a practice of retaining significant numbers of cels and other animation-related materials early in their history. The collection was stored in a basement on the studio lot until the establishment of the Walt Disney Animation Research Library (ARL) in Glendale, California, in the early 1990s (Smith 2006, Witkowski 1994). As a result, the ARL nowadays houses the world's largest repository of animation-related materials, with approximately 500,000 animation cels along with a collection of nearly 65,000,000 objects, mostly works on paper, stored in climate-controlled vaults at 47%RH and 16.5°C.

Even though the ARL cel collection has been carefully stored and protected, some of the plastic sheets show evidence of deterioration that is typical for cellulose ester plastics, such as buckling, warping, discoloration, and off-gassing. Not surprisingly, paints and inks on these sheets tend to develop problems of cracking and delamination. Approaches used for film preservation can only be applied to a certain degree (Reilly 1993, Nishimura 2015), as they do not address the specific challenges resulting from the combination of plastic sheets and applied paints.

A project by the Getty Conservation Institute (GCI) and the ARL aims to investigate the effects of storage environment on the condition of animation cels and develop new approaches for minimally invasive conservation treatment of damaged paints. A multidisciplinary team faces the challenge of preserving a collection of functional paintings that were originally expected to last only for the duration of the film production and never meant to be archived.

A condition survey of a representative group of animation cels, which were produced between 1937 and 1989, proved to be a valuable tool in this project. The survey helped in guiding

Figure 1. *The Jungle Book* 1967. Detail of black outlines that are inked on the front side. © Disney Enterprises, Inc.

Figure 2. *The Jungle Book* 1967. The paint is applied on the reverse within the outlines, detail. © Disney Enterprises, Inc.

observation of their condition across the timespan of their production, in characterizing the plastic sheet and paint materials, and in understanding the complex deterioration processes. This article presents broad perspectives and detailed findings that emerged from the condition survey as well as from material studies, focusing on the gum arabic–based paints developed and produced at the Disney Ink & Paint Department between 1936 and 1986.

2. INTRODUCTION TO CONDITION SURVEY AND MATERIAL STUDIES

The animation cel collection at the ARL mainly consists of "production cels" (fig. 3) that were photographed in making the film, and "color models" (fig. 4) that served as color references of the characters to the inkers and painters. Given the immense size of the collection, a decision was made to study a representative, yet reasonable, number of cels in the survey by limiting the selection to feature films with approximately five years between each release. Cels in the survey came from the following films: *Snow White and the Seven Dwarfs* 1937, *Fantasia* 1940, *Bambi* 1942, *Melody Time* 1948, *Cinderella* 1950, *Peter Pan* 1953, *One Hundred and One Dalmatians* 1961, *The Jungle Book* 1967, *Bedknobs and Broomsticks* 1971, *The Rescuers* 1977, *The Fox and the Hound* 1981, *The Black Cauldron* 1985, *The Little Mermaid* 1989. For each film, two storage boxes each for production cels and color model cels were randomly picked. In total, 5700 cels were surveyed.

As part of the project to investigate the material composition of the sheets and paints Fourier transform infrared spectroscopy with attenuated total reflection (ATR-FTIR) and gas chromatography-mass spectrometry (GC-MS) were used (GCI 2016).[2] Information from an earlier study that focused on characterizing the polymers and plasticizers in the plastic sheets was used for reference (McCormick et al. 2014, Giachet et al. 2014). Archival documents retained at the ARL proved to be important sources of information. Laboratory notebooks, paint recipes, reports, correspondence, supplier's details, inventory lists, product catalogues, and datasheets document developments in practices and materials in Disney's Ink & Paint Department, changes in formulations over time and occasional technical difficulties.

Figure 3. *The Jungle Book* 1967. Production cels were photographed for the actual film, and subsequently stacked according to their sequence in a scene, here with polyethylene interleaving layers, 30 × 41cm. © Disney Enterprises, Inc.

Figure 4. *Bedknobs and Broomsticks* 1971. Color model cels served as character color reference, and were stapled to their corresponding drawings and color notes, each cel representing a different character of a scene, 30 × 41cm. © Disney Enterprises, Inc.

3. METHODOLOGY

The condition survey, based on protocols by Bacci 2012 and Höyng 2010, was conducted entirely within one of the climate-controlled storage vaults. In order to highlight the onset of deterioration phenomena, the survey began with cels from the most recent production and progressed backward in time to the oldest cels. The survey was divided into five main categories:

1. *Storage condition*: presence of an odor inside of the box, dividers, and intermediate layers
2. *Sheet condition*: color shifts, sheet distortions, and surface deposits
3. *Ink condition*: ink dislocation and loss
4. *Paint condition*: loss of adhesion, paint cracks, paint loss, paint dislocation, and accretion
5. *Imaging and analytical measurements*: Selected cels were imaged in reflected and raking light from the front and the reverse, using UV-induced luminescence in the visible range to visualize adhesion loss, transmitted light to reveal paint application and distribution and using crossed polarizing filters to capture areas of sheet distortions and stress. Cel thickness was measured with a micrometer, and the polymer type was identified by ATR-FTIR spectroscopy.

A FileMaker Pro database stored the visual observations, images, scientific measurements, and comments from each category in the survey. For most categories, the number of cels per box affected by a given phenomenon was recorded, along with a description of the intensity (weak, moderate, strong, and very strong). The general condition was determined by an overall impression of the state of the sheet and paint within one box and divided into four categories: good, stable, unstable, and unacceptable.

4. OBSERVATIONS

From *Snow White and the Seven Dwarfs* 1937 to *Bambi* 1942, observations from the condition survey were based on an average of 27 cels per production. For *Melody Time* 1948, nearly 200 cels were surveyed. From *Cindere*lla 1950 to *The Little Mermaid* 1989, an average of 600 cels per production were studied.

4.1 Storage

Cels are housed at the ARL in archival boxes stacked onto baked-enameled metal compact shelving within each vault (fig. 5). The sizes of archival boxes vary from small (8 × 34 × 44 cm), to medium (13 × 34 × 44 cm), and large (8 × 44 × 115 cm) and are made from either gray or yellow cardboard. The box size for production cels varies according to the cel size (32 × 41cm is the typical size, but the width can vary), whereas color model cels (which are larger) are usually folded to fit into small or medium-sized boxes. Medium-sized boxes that are completely filled with animation cels hold approximately 340 cels and weigh up to 15.2 kg. From the survey, it was found that the average archival box holds approximately 150 cels for productions between 1950 (*Cinderella)* and 1989 (*The Little Mermaid)*.

The survey revealed a certain amount of variability in the way in which cels are packed within the archival boxes. Typically, production cels are stacked in cel mats[3] or between archival or nonarchival boards, which are held together with rubber bands (fig. 6). Each stack corresponds to one scene of a sequence, which means that the stack would hold similarly painted sheets (fig. 4). Interleaving layers of archival paper or polyethylene

Figure 5. Animation cel cold storage vault at the Walt Disney Animation Research Library. © Disney Enterprises, Inc.

Figure 6. *One Hundred and One Dalmatians* 1961. Open box shows cardboard sandwiches, each representing one scene of animation cels. © Disney Enterprises, Inc.

usually separate cels from one another. Generally, color models are stapled together in stacks to their corresponding drawings on paper—with each cel representing a different character of a scene (fig. 5)—and housed in four-flap document preservation binders that are closed by a button and string. Interleaving materials for color models range from archival papers, Xerox paper,[4] tracing papers to other nonarchival papers, but in actual practice were seldom used. It should be noted that portions of the collection have been repackaged by ARL staff for numerous reasons throughout their history, which often led to differences in the inner housing materials.

4.2 Paint

Between 1936 and 1986, the Disney Ink & Paint Department formulated their own gum arabic–based paints with the help of a staff chemist. Developments in paint formulations during this period are recorded in lab notebooks, recipes, reports, and other documents that are housed at the ARL. These documents show that, with a few exceptions, typical paint formulations included pigments, fillers, gum arabic binder, humectants, wetting agents, and preservatives. Although the basic recipe stayed similar over the years, alterations of paint properties are visible. In 1986, the Ink & Paint Department began formulating and producing the so called "acrylic palette"[5] and later switched to commercial available animation cel paints.

4.2.1 Paint characteristics

On the basis of information obtained from the condition survey, three main periods can be formed reflecting the materials and characteristics of the paints made at the Disney Ink & Paint Department (table 1). For productions between 1937 and 1942, paint properties vary in thickness and surface structure even within one character on a cel. Opacity and density vary with the thickness of the paint layers (fig. 7), and these early paints seem more brittle than paints from later periods. Productions from 1948 to 1953 show an obvious transition in painting technique, in which paints have distinct thicknesses, often appearing either grainy and very matte, or smooth and semiglossy (fig. 8). Paints from productions between 1961 and 1985 are characterized by flexibility, uniform thicknesses, very smooth and even surfaces, and a satin shine that differs slightly between colors. All brushstrokes are evened out and the paints do not thin out at the boundary of colors (fig. 9).

Table 1. Paint Characteristics and Condition.
This table refers to gum-based paints formulated at the Disney Ink & Paint Department from 1937 to 1985. The condition reflects observations for production cels.

Paint characteristics and condition				
1937	1948	1953	1961	1985
characteristics				
grainy or smooth				smooth
brittle				flexible
varying thickness				uniform thickness
condition				
cracks				
adhesion loss along cracks				
paint delocation or loss				

Figure 7. *Fantasia* 1940. Detail of varying paint application in thickness and structure, cracks and losses visible in transmitted light. © Disney Enterprises, Inc.

Figure 8. *Cinderella* 1950. Paint has a more distinct thickness, some colors are smooth others are grainy with a very matte shine, detail, reverse, raking light. © Disney Enterprises, Inc.

Figure 9. *The Jungle Book* 1967. Paint shows a distinct thickness and a very smooth and even surface structure with a satin shine, detail, reverse, raking light. © Disney Enterprises, Inc.

The characteristics of black colors do not follow the trends represented by the other colors. For instance, some black paints are bodied and matte, whereas others are very thin and shiny, even on one cel. Also, black is the only color that was painted either on the front or the reverse.

4.2.2 Document research

Observations of the periods can be correlated to binder concentration and humectant types obtained from studies of archival documents at the ARL and are consistent with GC-MS analysis of paint samples. According to a representative recipe from 1938, an early binder composition in paints with pigment-to-binder ratios of 1:1 contained gum arabic binder, glycerin as humectant, *Santomerse S* as surfactant, and *Dowicide A* as preservative. For the transition period from the mid-40s to the mid-50s, a change of humectant to sorbitol was found in requisition documents, which list a product called *Arlex*, an aqueous solution of D-sorbitol, and other polyhydric bodies made by the Atlas Powder Company (Atlas Powder Company 1951).

Correspondence with the Atlas Powder Company from 1956 suggests the addition of *Sorbitol Special* to *Arlex* to solve adhesion problems due to possible slight changes of the product *Arlex*. GC-MS results verify the introduction of a sorbitol derivative (1,4-anhydro-D-glucitol) in addition to sorbitol, starting in the mid-50s and fully implemented in the early 60s. For the later paint period (between 1961 and 1985), a typical recipe dated 1968 lists gum arabic binder, *Arlex* as humectant, *Aqualoid* as surfactant, and *Dowicide A* as preservative. The *Sorbitol Special*, which is not listed in recipes may have been added by the manufacturer. According to recipes, later paints have pigment-to-binder ratios of approximately 1:2, thus typical later paints contain twice the amount of binder compared to the early paints.

Black paint recipes indicate that a diverse range of binding media was used: gum arabic, animal glue, cellulose ethers (such as *Cellosize*, a hydroxyethyl cellulose), casein, polyvinyl acetate (PVA), and alkyd resins. However, gum arabic and cellulose derivatives were the only materials confirmed by GC-MS analysis of 15 black samples from 1940 to 1986.

4.2.3 Paint condition

The main defects observed in paints are cracking (figs. 7, 10), loss of adhesion (fig. 11), dislocations (fig. 12), and losses (figs. 7, 11). Instead of peeling from edges, paint lifting actually begins with small spots within painted areas that become larger. A correlation between cracks and loss of adhesion is obvious, as paints were often observed to be lifting along cracks.

Figure 10. *Bambi* 1942. Tent-shaped lifting paint, detail, reverse, raking light. © Disney Enterprises, Inc.

Figure 11. *Bambi* 1942. UV-induced luminescence in the visible range visualizes paint delamination as darker areas, detail, front. © Disney Enterprises, Inc.

Figure 12. *Peter Pan* 1953. Dislocation of dark green paint, detail, front, ordinary light. © Disney Enterprises, Inc.

A general trend of paint damages for production cels can be drawn from the condition survey. In earlier paints between 1937 and 1942, nearly every cel exhibits cracking, delamination, and losses. In contrast, progressively fewer cels show these issues throughout the transition period (from 20% in 1948 down to 10% between 1950 and 1953). For the later paints between 1961 and 1985, less than 5% of cels exhibit cracks, adhesion loss, or paint loss. This timeline of paint damages correlates well with changes in paint characteristics and composition (table 1).

The condition of paints on color models is comparatively worse. Although general trends are less obvious, the condition is influenced by the current storage. Color model cels, which were folded to fit in storage boxes, exhibit paint cracking, and adhesion loss in bent areas. Furthermore, paint adhesion problems often occur when interleaving layers are absent. Other factors that affect paint condition may relate to the amount and care of handling during and after production.

For production cels between 1948 and 1985, considerable differences in paint condition were observed from box to box, even within one production, and often this was associated with certain colors. Blacks in particular tend to crack and flake more than other colors, exhibiting extreme crack patterns (fig. 13), which might be caused by variation in their formulations. Another aspect is the amount of paint represented on the cels. For instance, painted fairy dust cels with a minimal amount of paint are in almost pristine condition, whereas cels with characters containing a larger area of paint show more paint-related defects.

Often, paints from cels between 1961 and 1985 were observed to stick slightly to their interleaving layers. In extreme cases, the paint from a character may be partially or almost fully transferred to its interleaving tracing paper (fig. 12). When interleaving layers are absent, paints on adjacent cels may stick to each other. In these cases, some colors of a character may transfer completely, whereas others remain attached to the plastic sheet. GC-MS

Figure 13. *Peter Pan* 1953. Typical crack pattern of a black paint with a cellulose derivative as a binder, detail, front, transmitted light. © Disney Enterprises, Inc.

results confirmed that paints from this period contain a greater percentage of gum arabic and sorbitol. A document from 1956 (Bailey 1956) describes the properties of paint as follows:

"…When paint is considered dry, you should be able to scrape small particles off with your fingernail, not peel the whole area off as has been happening.

If humidity goes under 35%, paint will dry out and flake off cel. If it goes over 45%, paint will become sticky again."

These paint characteristics were investigated and confirmed in relation to changes of relative humidity (% RH) by testing the mechanical behavior of a cel in an environmentally controlled chamber.

4.3 Ink

From 1937 to 1953, all cels were hand-inked on the front side of the sheet. To make colored inks, the paint was diluted with "special water" (a mixture of water and *Santomerse S* surfactant). Thus, hand-inked outlines could be as colorful and matte as the paints, although of darker shades (fig. 14). Around the time of *One Hundred and One Dalmatians* 1961, the studio began making the transition to xerographically produced[6] outlines. Xeroxed outlines, which have a semiglossy shine, are less well-defined, less compact, and more dynamic, as this technique directly copies the lines in the animators' drawings (fig. 1). The condition survey showed some outlines were still hand-inked in *One Hundred and One Dalmatians* 1961, but most were Xeroxed (table 2). Although most Xeroxed outlines were black, colored Xerox lines were first observed beginning with *The Rescuers* 1977.

Table 2. Ink Materials and Characteristics.
This table refers to ink used between 1937 and 1989.

Ink materials and characteristics				
1937		1953	1961	1989
hand inked				xeroxed
well defined and colored lines				dynamic, less compact and single color lines

Figure 14. *Peter Pan* 1953. Hand-inked outlines are all colored, detail, front, ordinary light. © Disney Enterprises, Inc.

In general, the ink is in good physical condition. Ink defects were mostly observed on hand-inked outlines and rarely with Xeroxed outlines. Within the period of the hand-inked outlines, ink losses or transfers to interleaving papers were detected from a mostly weak to moderate extent on approximately 25% of cels, most likely caused by high levels of relative humidity. The greater severity of ink damages for hand-inked outlines can be correlated to the increased severity of paint damages within production cels of that time.

5. DISCUSSION

In total, roughly 5700 cels have been surveyed, accounting for approximately 1% of the animation cel collection at the ARL. The gum-based paints from the mid-40s to the mid-80s, which were formulated and produced at the Disney Ink & Paint Department, are very durable. They were observed to adhere perfectly to severely distorted sheets and to highly degraded sheets. In total, less than 5% of the surveyed animation cels exhibited any paint damage. Further, paint damages are more severe in earlier productions. This change in paint condition correlates with a shift in paint characteristics and components as seen in the condition survey and archival document research, verified by GC-MS. Apart from factors related to paint composition (such as the types and amounts of binding media and additives), other factors were observed to influence the paint condition, including packing within boxes, and past and current storage conditions. Since packing of production cels was carried out more carefully and consistently than for color models, the production cels are generally in a better state of condition.

6. CONCLUSION

The survey of the ARL animation cel collection proved to be an invaluable opportunity to observe and compare a large number of similar artworks from the first full-length animated feature *Snow White and the Seven Dwarfs* 1937 to the last, mostly hand-painted one, *The Little Mermaid* 1989. To summarize the large body of information, timelines outlined the use of sheet, ink and paint materials for Disney animation cels, their respective characteristics, and the onset and development of deterioration phenomena. The general condition of animation cels at the ARL is surprisingly good, considering that the climate-controlled cool storage facility has housed these materials for only 17 years out of their total lifetime. This study highlights the importance of a comprehensive condition survey in learning about a collection, building a necessary foundation for further treatment and environmental studies and developing guidelines for preventive conservation. Understanding the complexity of the collection's condition, such as colors that are prone to crack or paints that tend to stick, will impact the focus of subsequent minimally invasive conservation treatments for delaminating paints.

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NOTES

1. This article is based on the talk "A study of painted animation cels, their materials and degradation processes," a paper presented at AIC 44th Annual Meeting & CAC–ACCR 42th Annual Conference Montreal, Canada, 13–17 May, 2016.
2. The analytical characterization of the paints is ongoing as part of a PhD thesis at the University of California, Los Angeles by Carolyn Carta.
3. Cel mats are cardboard frames made out of archival board. Along the lower edge, a Mylar sheet is attached to the cel mat protecting the loosely inserted animation cels from dust and sliding during handling.
4. "Xeroxed paper" is used as a term for a nonarchival paper usually containing copied outlines of a character.
5. A paint sample form 1985 (black paint from a color model cel) was identified as Polyvinyl acetate, which indicates a transition period.
6. At the Disney Ink & Paint department, the equipment for the Xerox process spreads over three rooms. In the first room, the animators drawing is illuminated for the camera exposure. The second room contains the camera, exposing the image onto coated aluminum plates, which after exposure are coated with toner. In a third room, the toner is transferred to a sheet of cellulose acetate and fused to the cel through exposure to fumes of trichloroethylene.

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KRISTIN DEGHETALDI and BRIAN BAADE

Using Web-Based Projects to Promote Conservation and Engage Diverse Audiences

EXTENDED ABSTRACT

In 2014, FAIC launched a research survey "Charting the Digital Landscape of the Conservation Profession."* Initial findings showed that the conservation field would benefit from new and engaging methods to connect with the general public and allied professionals (art history, the sciences, etc.). The presentation outlined two web-based projects that focus on traditional easel paintings; the projects implemented digital media and web technology to appeal to nontraditional audiences.

Work on the "Kress Technical Art History Website," a site hosted by the University of Delaware, began in 2013. The aim of the site is to educate a wide audience, specifically educators functioning in a museum or university setting, as well as members of the public who have an interest in the materials, techniques, and technical investigation of traditional Western Easel Painting. The Kress Technical Art History site explores these aspects through guided slideshows, engaging the viewer through a step-by-step process for 18 Old Master Paintings that outline each stage of the creative painting process. Complementary information relating to historical art materials and analytical processes are also outlined. https://www.artcons.udel.edu/outreach/kress

A second interactive website hosted by Villanova University was also discussed. The site outlines the many stages of a two-year conservation project using a month-by-month timeline and geo-mapping software. Viewers are invited to virtually experience each step of the treatment of a 12 × 20 ft. 17th century Italian oil on canvas painting entitled *The Triumph of David*, including the initial examination of the painting, consolidation and cleaning, and finally filling and retouching losses. Additional sections of the website feature information relating to provenance and the art-historical background of the painting as well as the scientific examination and imaging that was carried out by the conservation team. A major goal of the site is to "demystify" the process of a complex and involved treatment process while emphasizing the specialized expertise required of conservators and technical art historians. The *Triumph of David* site provides users with accessible documentation that can be used by the art community to inform future research relating to the artwork. http://www.thetriumphofdavid.com/

The authors addressed practical aspects of the websites, including unforeseen challenges, user feedback, and suggestions for those planning future web-based projects relating to the field of conservation.

* Zorich, Diane M., "Charting the Digital Landscape of the Conservation Profession," *The Foundation of the American Institute for Conservation of Historic and Artistic Works*, http://www.conservation-us.org/docs/default-source/reports/digital-landscape-report.pdf

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GIANFRANCO POCOBENE, JESSICA CHLOROS, and RICHARD NEWMAN

Carlo Crivelli's *St. George Slaying the Dragon*: Technique and Restoration

ABSTRACT

In 2015, Crivelli's St. George Slaying the Dragon *underwent a comprehensive technical examination and restoration in preparation for the first-ever monographic exhibition dedicated to the artist in the United States. Executed with astonishing skill in a variety of media, the painting exemplifies the artist's idiosyncratic manner characterized by dramatic compositions, remarkable illusionistic effects, and lavish decoration. Crivelli's meticulous facture was revealed through imaging and analytical techniques, including the artist's use of extensive underdrawing, the elaborate and skillful use of* pastiglia*, and confirmation that in addition to conventional gold-ground techniques, silver leaf was used to embellish the surface. The 2015 cleaning and restoration of the picture addressed aesthetic issues concerning the removal of an 80-year old PVA varnish, a wax coating, and old restorations followed by reintegration of losses to a high level of restoration.*

1. INTRODUCTION

In 1897, Isabella Stewart Gardner acquired Carlo Crivelli's *St. George Slaying the Dragon* (fig. 1) from Colnaghi in London on the advice of Bernard Berenson.[1] He described the painting as "a gorgeous thing . . . decorative as no other picture whatsoever, resplendent in its gold background, its gold armour and brocades. . . . You never in your life have seen anything so beautiful for colour, and in line it is drawn as if by lightning."[2] Crivelli's opulent and highly expressive compositions were prized by late 19th and early 20th century collectors, but his paintings have received considerably less attention than those produced by Florentine and Sienese schools. Last year, the painting was the inspiration and focal point for the first-ever monographic exhibition dedicated to Crivelli in the United States. *Ornament and Illusion, Carlo Crivelli of Venice* (Isabella Stewart Gardner Museum, October 22, 2015 through January 25, 2016) explored the multifaceted aspects of the artist's work and brought together 23 of the artist's paintings and his only known drawing. The *St. George Slaying the Dragon*, had not been treated in 80 years, and in preparation for the exhibition a thorough technical study and restoration of the painting was conducted, which revealed intriguing aspects of Crivelli's meticulous facture. The conservation of the picture, initially envisioned as a light cleaning with minimal retouching to correct discolored restorations, ultimately evolved into a more comprehensive treatment of both the painted and gold leaf surfaces.

Among the artist's most striking compositions, *St. George Slaying the Dragon*, dated around 1470, is one of six panel paintings that originally formed an altarpiece for a church in the Adriatic coastal town of Porto San Giorgio. The altarpiece had remained intact until the middle of the 19th century, when the polyptych was disassembled and its components sold off to various collections in Europe and America (Lightbown 2004). The painting exemplifies Crivelli's highly individual manner and bravura in a variety of media, including metal leaf, egg tempera, and ornamental relief. The picture depicts the dramatic moment when the youthful St. George, attired in richly decorated armor and mounted on a rearing white horse, is about to slay the dragon. The scene is set against a sky surfaced in lustrous gold leaf that along with lavish ornamentation creates visual tensions between the naturalistic rendering of the forms and the two-dimensional plane of the paint surface. The rich array of pictorial techniques is now diminished by the effects of time and past restorations, but many of the splendid visual and tactile features of his meticulous workmanship survive.

Figure 1. Carlo Crivelli, *St. George and the Dragon*, after the 2015 conservation treatment

2. TECHNIQUE AND CONDITION OF THE PAINTING

The techniques used by Crivelli to prepare the panel for painting generally follow the workshop conventions of his contemporaries; however, in the tradition of Venetian and Gothic art, three-dimensional ornamentation to create glittering surface effects were also employed. As is typical of early Italian pictures, the image is executed on a poplar support.[3] The wood panel has a vertical grain direction although the wood is not of the best quality. Overall, the panel has retained its original dimensions, although exposed woodworm tunnels along the proper right edge suggest that it was trimmed slightly along that surface. At some point in the late 19th century, before it entered the Gardner collection, the panel support was planed down to a thickness of half an inch (1.3 cm) and a moderate weight mahogany cradle was attached to its reverse. The Isabella Stewart Gardner Museum conservation records contain no mention of the cradle being attached to the painting while in the collection. The February 21, 1934, conservation-treatment entry suggests that it was applied in the late 19th century, which, given its construction and appearance, is a reasonable assertion. In preparation for painting and gilding, the workshop primed the wood panel with a layer of gesso composed of gypsum in animal glue, which was confirmed through SEM analysis. A cross section of the gesso layer was examined by Richard Newman, Museum of Fine Arts, Boston, using a JEOL JSM-6460LV scanning electron microscope with an Oxford Instruments "INCAx-sight" energy dispersive x-ray spectrometer (133 eV resolution @ 5.9 keV). Calcium and sulfur, the principal elements of hydrated calcium sulfate, were detected. In addition, the characteristic fibrous particles of the mineral were visually observed. In his *Il libro dell'arte*, Cennini describes in considerable detail the importance of the preparation and buildup of this layer where up to eight thin coats of the *gesso sottile* are applied to the panel (1933). Along the left, right, and bottom edges of *St. George and the Dragon*, where a half-inch-wide (1.3 cm) band of the gesso was left unpainted, the strata of these gesso layers are visible. Originally, this unpainted, white border would have been covered by the ornate frame that the painting was set into. There is no evidence of barbs (raised remnants of the ground) along the gesso edges of the panel to indicate that an engaged frame was present on the panel. An extensive craquelure pattern running in the horizontal direction is visible over much of the painted and gilded surface although the paint and ground layers remain stable. Also visible are a series of odd crisscrossing diagonal cracks in the gesso surface. The cracks in the gesso also appear as faint whitish lines in the x-ray radiograph but their cause is undetermined.

X-ray radiographs of the painting reveal no significant changes in the composition, which speaks to the disciplined workshop practices of the period. X-ray radiographs of the panel were made by Gianfranco Pocobene in December 2012 at the Straus Center for Conservation and Technical Studies, Harvard Art Museums. The outlines of the lead white pigments are barely visible in the x-rays, but the dense lead putty fills, used in the

previous treatment to fill the numerous wormholes and associated damages, are more prominent. Fainter still are randomly applied pieces of thin, open-weave fabric applied to the panel surface before the application of the gesso layers; a preparatory technique also described by Cennino Cennini. Along the lower right edge of the painting, a poorly restored vertical split in the wood is visible. The x-ray radiograph reveals that a wood insert measuring $4\frac{1}{8} \times 1\frac{1}{4}$ in. was set into the lower-bottom-right corner in a previous restoration to repair what must have been severe damaged to the corner of the panel.

Infrared reflectography (IRR) of the painting reveals that Crivelli made a skillful underdrawing of the composition on the gesso surface using a fine brush and carbon-rich black ink. IRR imaging was performed by Pocobene at the Poorvu Family Conservation Center, Isabella Stewart Gardner Museum, using a PhaseOne P45+ digital sensor (5412 × 7216 pixels) with the IR filter removed and fitted on a Mamiya medium-format camera body. The sensor is capable of detecting infrared radiation in the 780–1150 nm range. IR images were taken through an 87A filter. In the head of St. George, for example, the fluid brush lines define the contours of his face, eyes and eyebrows, and the gentle waves in his hair. Features of the horse's head are similarly treated, and here the thin, sharp ends of the lines where the brush tip first makes contact with the gesso surface become wider and more apparent as pressure is applied (fig. 2). A characteristic feature of Crivelli's technique is that in the late stages of painting, he sometimes reinforces contours with thin black lines of paint. These are considerably darker in appearance and make the underdrawing lines next to impossible to discern. Except for a slight shift in the position of the horse's teeth, the completed image does not stray from the initial underdrawing. While it is conceivable that an initial transfer technique from a drawing was used, no evidence of pouncing is visible in the IRR images, suggesting that if such a transfer method was used, the spolvero was rubbed off after the wet-media underdrawing was laid in.

Figure 2. Infra-red reflectography image showing underdrawing lines composed of black ink in the heads of St. George and the horse

A hallmark of Crivelli's work is his elaborate use of *pastiglia*, a technique that Cennini describes in his treatise (1933, 76–77). The surface of *St. George and the Dragon* is embellished with these low-relief elements and are especially notable in St. George's halo, the hilt of his sword, his armor, and the horse's bridle. The most prominent of these forms are the round, star-patterned studs that decorate the horse's bright red bridle and reins (figs. 3 & 11). The technique involves the buildup and carving of layers of gesso on the panel surface to create subtle shapes and patterns that project out from the otherwise flat surface. Pieces can also be cast in gesso from premade forms that are then attached to the surface with liquid gesso. These relief elements are further refined by the application of a thin coat of gesso followed by shaping with a knife. Originally, all of these relief elements were overlaid with gold leaf to enhance their three-dimensional qualities, an effect that would have been conspicuous in the flickering, low light produced by candles on a church altar. Depending on the movement and position of the viewer, the shimmering surfaces would have been dazzling, but because the gold has worn away from many of the *pastiglia* elements, these glittering effects are greatly reduced. Where the gold leaf has worn away from the *pastiglia* surfaces, the creamy white color of the gesso buildup is not revealed, but, rather, a dull flesh color is evident. Cennini's recommendation that red clay be added to the *pastiglia* material to give it color to make the relief elements easier to see and work with was employed by Crivelli as all of the abraded *pastiglia* elements are dull pink in appearance (1933, 73).

Figure 3. *St. George and the Dragon*, detail after treatment, normal light

To reveal the physical characteristics of the *pastiglia* and extent of its use in the decoration of the panel, reflectance transformation imaging (RTI),[4] was utilized in the study. The snapshot image taken from the RTI imaging illustrates not only the extent of the relief applications but also the sophisticated 3D effects achieved with the technique (fig. 4). In addition to revealing the shape and surface qualities of the large ornamental studs that decorate the horse's bridle, for example, the RTI imaging reveals subtle textures such as the fish-scale pattern on St. George's armor, which in normal illumination appears as a series of delicate, curved gold accents over the blue background.

Gold leaf plays a prominent role in the works of Crivelli and is used to great effect in the painting. In the sky, which creates a lustrous backdrop for the scene, the overlaid edges of each individual sheet of gold leaf are evident as well as areas of the red bole preparation exposed during previous cleanings. The *pastiglia* reliefs throughout much of the image are also surfaced in gold leaf to accentuate their 3D qualities. In addition to applications in leaf, finer delicate passages, such as the fish-scale relief pattern of St. George's blue armor are surfaced in gold in a mordant technique. This allows for passages already painted in egg tempera to be decorated with gold using an oil-based adhesive. The thin gold stripes on the scarlet hilt of the sword (fig. 5), also embellished with mordant gold, demonstrate the fine effects that can be achieved with this technique.

Careful examination of the paint surfaces reveals the characteristic traits of egg tempera, which forms the basis of the composition. Unlike oil paint, which can be applied in various consistencies ranging from thin glazes to thick impasto layers, egg tempera has limited handling properties that restrict its application to a hatching technique, whereby the forms are built up with repeated applications of thin lines of paint using a fine brush. The individual hatches of egg tempera applied with a fine brush are most evident in the horse's white hair and mane.

Figure 4. Detail, reflectance transformation imaging (RTI specular mode) revealing the topographical characteristics of the *pastiglia* relief work

Figure 5. Detail showing incision lines in gesso that delineate the contours of tempera paint in hands from the gold leaf background. Mordant gold stripes are visible in the hilt of the sword

To better understand the range of pigments used by Crivelli, XRF analysis was conducted on 21 locations over the painting surface. XRF analysis was performed by Jessica Chloros and Pocobene using a Bruker Tracer III-SD spectrometer S1PXRF and ARTAX, 7.4.0.0 software with interpretation of the data conducted by Chloros.[5] Not surprisingly, Crivelli used a selection of pigments typical of the period. For the most part, earth pigments are the predominant colors used to create the composition, however, two colors in particular stand out. The blue scale-patterned armor that protects St. George's body, which has a remarkable resemblance to the blue-skinned scales of the dragon, is composed of the copper-based pigment, azurite to which white lead was added to lighten its tone. The scarlet red used in St. George's tunic, the horse's bridle, and the red helix stripe on the broken lance is composed of vermilion or cinnabar, the brilliant pigment that dates back to antiquity.[6] Although worn in a few areas, the passages painted in vermillion have aged well and retain their intense hue.

Crivelli employed a striking ornamentation technique in the small cabochon that adorns St. George's forehead. The gemstone is fashioned from a raised *pastiglia* element overlaid with gold leaf and then toned with a transparent red glaze to mimic the effect of a transparent jewel. Unlike the egg tempera used elsewhere, the aluminum peak in the spectrum indicates that an organic lake pigment precipitated on alum and likely suspended in oil medium was used. Although the red lake pigment cannot be detected with XRF, aluminum, the base on which the dye is precipitated during its manufacture, was evident in the

XRF spectra. Unfortunately, a large portion of the red glaze and gold leaf is now worn down to the *pastiglia* surface, and its overall effect is not what it once was. Nonetheless, the edges and lower portion of the relief suggest the brilliant quality the painted gemstone surface originally possessed.

During the technical study, particular attention was given to St. George's armor, which presently has an odd, dark brown color. Interestingly, a note in the 1935 condition report described this area as being composed of silver leaf, "discolored nearly black by corrosion."[4] To confirm the possibility that Crivelli may have used silver leaf in painting, XRF analysis was performed at four locations on the armor and the blade of the sword. Notable silver peaks evident in the XRF spectra were detected in all four locations, which instigated further analysis. Microscopic examination of a cross section of paint taken from the proper left arm just below the elbow cap did not reveal the existence of silver leaf in the sample most likely because of the badly tarnished condition of the thin metal layer. The cross section was taken by Pocobene and examined using a Zeiss Axio Imager.M2m fluorescence microscope. Its presence and location within the paint layers, however, were detected with SEM. In the SEM image, the bright layer of silver is clearly evident near the very top of the sample. The analysis also detected the presence of sulfur, confirming that the silver leaf has indeed tarnished to silver sulfide. Richard Newman, Museum of Fine Arts, Boston, detected the silver leaf layer and sulfur, confirming Ag2S corrosion, using a JEOL JSM-6460LV scanning electron microscope with an Oxford Instruments "INCAx-sight" energy dispersive x-ray spectrometer (133 eV resolution at 5.9 keV). Interestingly, Cennini warns that silver should not be used much in painting, "because it does not last; and it turns black"(1933, 60). Artists of the period, however, appear not to have heeded his advice, as it has been found with some regularity on early Italian paintings. The SEM analysis in this area revealed another interesting aspect of the Crivelli's technique. A pigment layer containing bone black, which appears as a dark intermittent layer in the image, was detected over surface of the silver leaf. This layer appears to be original and represents a toning layer applied along the right edge of St. George's upraised arm to create a shadow. A more careful look at the paint surface indicates that the left edge of the arm is also toned to enhance its form, however, that side is highlighted with thin strokes of white tempera to indicate where light coming from the left strikes that edge. The composition of these surfaces indicates that the dark brown armor and sword were originally a lighter, silvery color modeled with pigmented glazes to give them 3D form (fig. 6).

Figure 6. Detail of tarnished silver leaf in St. George's armor with shading tones on the right edge and highlight paint strokes on left edge

3. CONSERVATION TREATMENT

The last conservation treatment of *St. George Slaying the Dragon* was carried out in the mid-1930s. During that treatment campaign, actively blistering paint and ground layers in the upper left quadrant of the panel, attributed to the restrictive properties of the cradle, were stabilized with gelatin size. The November 19, 1934, conservation treatment entry describes the blistered condition of the paint film, especially in the upper left quadrant. This problem required regular attention up until 1940, but since then, the problems have not reappeared.[7] Since then, the panel has remained remarkably stable with no further reoccurrences of flaking. The treatment of the painting, which was carried out by George Stout over the course of a year from November 1934 to November 1935 is extensively

documented in the Gardner Museum conservation records with 18 pages of dense, handwritten notes and drawings. By contrast, there are only three photographs that document the condition of the painting at that time. The earliest photograph of the painting and the only one that predates the 1934–35 treatment is dated 1926 (fig. 7). It documents the condition of the paint surface just two years after Isabella Gardner's death, and as no treatments were carried out on the picture during her lifetime, this image most likely represents the condition of the paining at the time she purchased it.

Figure 7. Carlo Crivelli, *St. George and the Dragon,* 1926 photograph showing the condition of the painting prior to the 1934–35 conservation treatment

After Stout stabilized the paint surface, cleaning of the panel was undertaken to remove what were described as three distinct film layers on the paint surface. The first cleaning entry reads in part as follows:

> The surface film uppermost . . . was easily and safely removed with diacetone alcohol. Below it was found a distribution of spots of repaint, stains of an old varnish . . . The varnish stains and repaint were soluble in acetone and benzene and were quite safely removed. This left . . . an old much darkened oil-resin film next to the original paint and actually saturating it at the surface. The distribution of this layer was not at all uniform, and its confines were largely within the dark and thin areas of the original paint.[8]

While the upper two film layers were easily removed, the uneven remnants of the oldest film proved to be considerably more tenacious. Numerous combinations of solvents and reagents in various ratios were tested on the paint surface. These included solvents such as triethanolamine, methyl alcohol, diacetone alcohol, ethylene dichloride, acetone and even a 1:1 mixture of ammonium hydroxide and methyl alcohol. Some of the test-cleaning mixtures were suspended in beeswax to formulate paste wax cleaners, which would leave a saturated paint surface after cleaning. It is noted in the report that these formulations invariably lead to "a slight softening of the of the whole structure, paint film and surface film in the lean areas of the former."[9] In the end, the dark stains concentrated at the left of the picture were thinned with a mixture of triethanolamine, 1 part; methyl alcohol, 2 parts; and acetone, 2 parts, with the amount of exposure timed so as not to affect the lean and porous portions of the painting. A 20% ammonium hydroxide in acetone solution was also employed for the remaining stains. The 1935 during-cleaning photograph, which is only one of two taken during the treatment, reveals that the cleaning was dramatic; however, numerous losses and abrasions were uncovered in portions of the surface.

The second during cleaning photograph of the work (fig. 8), taken after cleaning was completed, suggests that more of the gesso layers were exposed through the cleaning process, especially in the cliffs at the left where the forms have become almost indistinct. In describing the condition of the painting the report states:

Figure 8. *St. George and the Dragon,* after cleaning image showing extent of abrasions revealed during the 1935 restoration

> In the architecture there was moderate abrasion and a moderate loss from flaking. The landscape suffered only from slight abrasion, wormholes and a few scratches. The cliff at the left was badly mutilated by flaking, abrasion, deep scratches, and a number of wormholes. The same was true in the foreground, especially in in the upper part. The dragon was somewhat abraded particularly in the wings and in the lower part of the body. Below the breast of the horse there was extensive loss from the same causes.[10]

Of considerable concern is the question of when did the damage to these passages occur? Did the 1935 cleaning simply reveal damages already present from previous cleanings or did more damage occur as a result of the effort to thoroughly clean the paint surface? The lack of information about this in the report and sparse photographic documentation makes it difficult to be certain, but the use of the rather aggressive cleaning solutions employed in 1935 would suggest that more damage and skinning of the paint surface may well have occurred during the cleaning.

Once the cleaning was completed, PVA, with toluene as the principal solvent (methanol, diacetone alcohol, and ethylene dichloride) was brush applied to the painting. The application of a PVA varnish to the Crivelli painting represents one of the earliest uses of this material at the Gardner Museum. Because of their stability, flexibility, and adhesive properties, these resins have been used extensively in the field of conservation. In the mid-1930s the possibility of using PVA resin in conservation was proposed.[11] The numerous scattered losses and abrasions over the paint surface were restored with pigments mixed in an egg-and-gum medium. Finally, the painting surface was coated with a thin layer of wax and buffed to achieve an appropriate sheen. As no other treatment of the painting has taken place since 1935, the 2013 before-treatment image represents the extent and level of restoration carried out by George Stout (fig. 9).

The 2015 restoration focused on visually disruptive problems related to the absorption of grime by the varnish, yellowing of the wax coating, and restorations that no longer matched the original paint layers. Also troubling was the extent to which many of the old damages were left unrestored. While some concern has been expressed about the solubility of early synthetic varnishes, the 80-year-old varnish layer along with the wax coating was removed with relative ease using xylenes and ethanol (fig. 10). Much of the inpainting from 1935 was also removed during this process, but many of the previous restorations were left in place to reduce exposure of the damaged paint layers to solvent action. It was also decided that exposing all of the losses and abrasions served no real purpose. In fact, many of the old restorations were not badly discolored and could serve as a foundation for the current restoration.

As already mentioned, the 2015 conservation treatment was undertaken to address aesthetic issues, mainly the presence of a dingy varnish layer and restorations that no longer matched the original paint layers. Although the Crivelli exhibition was the impetus for proceeding with the treatment, another and equally significant rationale for cleaning and restoration is the painting's context and relationship to the objects and wall coverings in the Raphael Room, where it is permanently displayed. Presently, a full-scale restoration of the gallery is underway at the Gardner Museum and a significant component

Figure 9. *St. George and the Dragon,* before the 2015 restoration

Figure 10. *St. George and the Dragon,* after cleaning image and before in-painting, 2015

of the work includes the commissioning and reinstallation of wall fabrics as installed by Isabella Gardner in 1903. The current replacement wall fabrics dating to the early 1970s do not accurately reflect the 19 different patterns of damask, brocade, and velvet patterns that Gardner originally placed on the walls. The appearance and textures of the walls will be considerably more varied and dramatic and so context was also a major consideration when thinking about the appropriate level of restoration for the Crivelli.

To determine the level extent of inpainting and toning to be performed on the painting, much time was spent comparing the 1926 archival photograph (fig. 7) with the state of restoration as executed by Stout (fig. 9). The most striking aspect of the 1935 treatment was the cursory approach that was taken to restore many of the forms and passages throughout the composition. In many areas, losses were not accurately matched for color, but rather, a neutral tone was applied to knock back the exposed white gesso. Many problems stand out,

but the most obvious are the rocky cliffs below the town that were left in a state of incompletion. A more subtle, but nonetheless significant problem, is the lack of modelling in many of the forms such as the belly of the horse, which appears flat and undefined when compared to its state in 1926. In mid-20th century American conservation, early Italian paintings were often left minimally restored in an effort to present the paintings in their true state condition. Unfortunately, this treatment approach compromised the aesthetic qualities of the painting making the appreciation of the image for the viewer next to impossible.[12] The most controversial example of this occurred with the Jarves pictures at Yale University where heavily cleaned panel paintings were left in a raw state of presentation. As for the present restoration of the Crivelli, the more highly restored 1926 appearance was deemed more aesthetically pleasing than the way it was treated in 1935. Last and most important in these considerations is Crivelli's technique. His pictures are elaborate and lavish creations and as such require a more thorough level of completion to hold the image and surface effects together. To that end, the inpainting phase of the work performed in 2015 aimed at imitating the precise painting technique used by the artist, namely, the careful buildup of paint layers with a hatching technique. In preparation for inpainting and toning, a thin isolating layer of Paraloid B-72, 8% in ShellSol 100 was brush applied to the painting. Old, uneven repairs in the surface were leveled with Modostuc (chalk in PVA medium) followed by inpainting and toning with Golden MSA pigments. Reconstruction of the damages was aided by images of the 1926 archival photograph but most importantly by looking carefully at the surface of the painting where enough evidence remained to carry out the work (fig. 1). A final spray coating of Conserv-Art Gloss Varnish (Windsor & Newton) diluted (1:1) in mineral spirits was applied to the panel.

Concurrent with the restoration of the painted surfaces, consideration was also given to the abraded and uneven state of the gold-leaf surfaces. In a few selected areas of the sky, especially along the top of the left edge, 23K gold leaf was applied with an acrylic emulsion size to repair unsightly expanses of the red bole under-layer, but otherwise, the sky was left as is. The loss of gold leaf in the *pastiglia* reliefs, however, greatly compromised the visual effects of these surfaces and required much more attention to ensure visual balance between those surfaces and the egg-tempera paint layers. Many trials were carried out to determine the

Figure 11. Detail of gilt *pastiglia* relief elements

appropriate technique for reinstating the gilt surfaces of the *pastiglia*. One such trial involved the application of gold leaf to the large studs in the horse's bridle. While probably approaching the original appearance of these surfaces, this was considered excessive as it obliterated signs of cracking and age far too much. After more testing, the reinstatement of the gold surfaces was finally achieved by selectively retouching the reliefs with shell gold (fig. 11). The technique and translucent quality of the shell gold allowed for controlled application of the material where it was needed and allowed for the cracks and the undertones to show through. As with the inpainting and toning of losses in the egg-tempera paint layers, the intent was to reinstate the reflective and lustrous characteristics of the gilded *pastiglia* so critical to the effects intended by Crivelli while also ensuring that the age of the painting remained evident throughout.

The restoration approach taken with the Crivelli is based on the history and particular condition of the painting and its context within a gallery installation as determined by a collector at a specific time. Other situations might call for a different approach, perhaps one where the extent of inpainting and toning of the surface might be more restrained. In the end, it is the careful study of a work of art and an interpretation of the artist's intent that determines the appropriate course of treatment.

ACKNOWLEDGMENTS

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NOTES

1. Isabella Gardner purchased the painting from Colnaghi & Co., London, in December 1897, Isabella Stewart Gardner Museum Archives.
2. Bernard Berenson to Isabella Stewart Gardner, November 24, 1897, Isabella Stewart Gardner Museum Archives.
3. Technical analysis of the Gardner panel has not been conducted to determine the wood species, although *Saints Peter and Paul*, National Gallery, London, NG3923, is described as being executed on poplar; http://www.nationalgallery.org.uk/paintings/carlo-crivelli-saints-peter-and-paul/★/key-facts.
4. For more information and examples of examining works of art with reflectance transformation imaging, see http://culturalheritageimaging.org/Technologies/RTI/. RTI was originally developed by Tom Malzbender and Dan Gelb at Hewlett-Packard Laboratories.
5. For details on the pigments identified in the painting, see "Crivelli, *St. George and the Dragon* XRF Analysis Interpretation Report" by Jessica Chloros, Paintings Conservation Files, Isabella Stewart Gardner Museum, February 14, 2015.
6. For information on the history and manufacture of vermilion, see Gettens, Feller, and Chase 1993.
7. Paintings Conservation Files, Isabella Stewart Gardner Museum.
8. June 10, 1935, entry, Paintings Conservation Files, Isabella Stewart Gardner Museum.
9. June 12, 1935, entry, Paintings Conservation Files, Isabella Stewart Gardner Museum.
10. August 26, 1935, entry, Paintings Conservation Files, Isabella Stewart Gardner Museum.
11. See Gettens 1935.
12. For more on the history and treatment of paintings in the Jarves Collection at Yale University, see Garland 2002.

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Lightbown, Ronald. 2004. *Carlo Crivelli*. New Haven: Yale University Press, 109.

SOURCES OF MATERIALS

Paraloid B-72
Rohm and Haas Co.,
Philadelphia, PA 19105

ShellSol 100
Shell Oil,
P.O. Box 2463,
Houston, TX 77252

Modostuc
Plasveroi S.p.A.,
Via Camussone 38,
Franzione Giovernenzano,
Vellezzo Bellini, PV, Italy

Golden MSA Pigments
Golden Artist Colors, Inc.,
188 Bell Road,
New Berlin, NY 13411-952

23K Gold Leaf
Giusto Manetti Battiloro S.A.S.,
Via Tosca Fiesoli,
89 M50013 Campi Bisenzio,
Florence, Italy

Lucco Aquasize
Leo Uhlfelder Co.,
Mount Vernon, NY 10553

Conserv-Art Gloss Varnish, (discontinued and replaced with Artists' Gloss Varnish)
Winsor & Newton,
11 Constitution Avenue,
Piscataway, NJ 08854

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DINA ANCHIN

Exploring Pieter De Hooch's Mid-Career Period: A Study of Growth in Creativity

ABSTRACT

Pieter De Hooch's mid-career period is considered his most artistically creative phase. During this time, he worked first in Delft and then Amsterdam, and his paintings became more refined in technique and innovative in subject matter. This study investigates De Hooch's painting methods, specifically his technique, painting practice, and material choices, during this period. It includes the examination of 35 paintings, and while most date to the mid-career period, some artworks from his early and late career were examined to put findings in context.

1. INTRODUCTION

In the course of Pieter de Hooch's artistic career, both his style and technique of painting evolved, shifting in response to his contemporaries' work as well as to the current interests of the art market. As De Hooch came into artistic maturity in the mid to late 1650s, entering what is considered his most artistically creative period; his paintings became more refined in technique, sensitive in palette and composition, and innovative in subject matter. In the late 1650s, De Hooch began creating carefully composed domestic scenes of mothers and housewives, paying deliberate attention to naturalism, light sources, and quality of light. As the mid-career period progressed, his subject matter shifted to the depiction of more prosperous households and elegant genre scenes. Despite this change in subject, there was still sensitivity to spatial order, naturalism, and perspective throughout all the mid-career compositions. The technical quality of these paintings remains strong, differing both from his earlier works, which were mainly low-life genre compositions painted in a sketchy manner with a dark, earth-toned palette, and also from works of his later period, when, in reaction to the economic decline of Amsterdam in 1672, De Hooch began to produce more paintings but at the expense of their quality.

Although art historical literature on De Hooch's life and artistic career exist, there is a dearth of material regarding his technique, material choices, and how these evolved over the course of his career. This study investigates De Hooch's painting methods, specifically his technique, painting practice, and material choices, during his mid-career period. The three paintings by De Hooch in the National Gallery of Art's collection—*A Dutch Courtyard*, *The Bedroom*, and *Woman and Child in a Courtyard* all dating from 1658 through 1660—are a main focus of this study, though examination of a number of De Hooch's paintings in other institutions played an integral role, further adding to the knowledge base of the artist's painting technique and materials choices. In addition, while these mid-career paintings are the focus of the study, some artworks from his early and late career were examined in order to put findings in context and to better understand how De Hooch's technical practice evolved over the course of his career. Last, treatment and technical analysis of one of the National Gallery of Art's paintings, *Woman and Child in a Courtyard*, complemented the study and overall findings.

2. PIETER DE HOOCH AND HIS ARTISTIC CAREER

Pieter de Hooch apprenticed with the Italianate landscape painter Nicolaes Berchem in Haarlem along with fellow pupil Jacob Ochtervelt. Although De Hooch trained with a landscape painter, his early works show no evidence of this, with his compositions focused in the low-life genre, depicting soldiers in stables or inns, and scenes from the earlier traditions of guardroom paintings (Sutton 1998, 17). The soldiers and peasants are placed in the foreground of a dark interior, drinking, smoking, or playing cards. The use of yellow and brown earth pigments is abundant, especially in the background and foreground, in which a thin, sketchy brown earth pigment is generally painted on top a light-tan imprimatura or ground. The darker shades of brown and brown-black are used to help create form and space. The focus of these early paintings is on the subjects, despite their minimal action, rather than

the space they inhabit (Sutton 1998, 16). This aspect of De Hooch's compositions changed during his mid-career period. A good example of an early work is *Soldier Offering a Woman a Glass of Wine*, ca. 1653, The State Hermitage Museum, St. Petersburg.

In 1652, De Hooch was residing and working in Delft, and, in 1655, he was admitted to the Delft guild. By the late 1650s, De Hooch transitioned from painting dark barns and taverns scenes to orderly sun-filled interiors in domestic settings and courtyards, where there is an equal balance of figures within a setting, and a focus on light and atmosphere. It is at this time that De Hooch is described as being in command of his talent and an innovator "creating a new type of genre painting with unprecedented spatial order and naturalism" (Sutton 1980, 15; Sutton 1998, 26). His compositions are derived from careful observation, using multiple sources of light and multiple vanishing points, showing a great interest in and understanding of perspective, and his paintings appear thoughtfully composed. Along with the setting, the subject shifted to mothers and housewives often with children, performing their duties. All three paintings by De Hooch in the National Gallery of Art's collection—*A Dutch Courtyard*, *The Bedroom*, and *Woman and Child in a Courtyard*—are typical of his work from the Delft period.

Between 1660 and 1661, De Hooch moved to Amsterdam, and this led to further change in his compositions and subject matter—a shift from simpler middle-class figures and interiors or courtyards to finely attired figures and more elegant settings. Rather than quiet scenes with a few figures, he began to paint larger groups, including merry and musical companies. The paintings from this time are even more geometrically ordered, sometimes with a finer execution. These qualities of the Amsterdam period can be seen in *Figures in a Courtyard Behind a House*, 1663, Rijksmuseum, and *Learning to Walk*, ca. 1665–1670, Museum der bildenden Künste Leipzig. Although the paintings appear balanced and planned, they were often a process, evidenced by a number of pentimenti and adjustments to the size, shape, and placement of objects and figures throughout.

During this period in the Netherlands, there was a marked degree to which artists inspired one another, and responded to one another's styles, techniques, and subject matter. Considering that De Hooch worked in two major cities, Delft and Amsterdam, the changes seen in his paintings must have been in part a response to his contemporaries. For example, based on an official record, a signed document, it is known that both De Hooch and Vermeer were working in Delft at the same time, and it is likely that their artistic relationship ran in both directions (Sutton 1998, 24). From comparing De Hooch's *Soldiers Playing Cards*, ca. 1657–58, private collection, with Vermeer's *Officer and Laughing Girl*, ca. 1657, Frick, New York, it is likely that during the late 1650s, when De Hooch was remarkably innovative, Vermeer looked to De Hooch for inspiration. On the other hand, when comparing De Hooch's *Woman Weighing Coins*, ca. 1664, Berlin, Staatliche Museen zu Berlin, Gemäldegalerie, with Vermeer's *Woman Holding a Balance*, ca. 1663–64, Washington, National Gallery of Art (NGA), it is evident their roles reversed, and De Hooch took inspiration from Vermeer's work.[1]

Around 1670, the noticeable decline in the quality of De Hooch's paintings may be attributed to strains on the Dutch economy from the war with England in 1665–1666 and the successful French invasion of the Netherlands in 1672 (Sutton 1998, 58). Although De Hooch remained an economical painter throughout his career, he was even more so in the later years, using a looser sketchier technique. He seemed to borrow subject matter more frequently from his contemporaries, whereas the works from his mid-career were more inventive. His late works were even grander in setting and size, depicting prosperous figures, and often, musical scenes. *The Greeting*, 1675, National Gallery of Art (formally in the Corcoran Gallery of Art's collection), is an example of a typical work dating to this period. The paintings produced during this period, from ca. 1670 until his death in 1684, are considered late works and will be referred to as such throughout this article, while artworks from the late 1650s through 1669–70 are considered mid-career-period artworks.

3. TECHNIQUE: INVESTIGATION OF MID-CAREER PERIOD

This study includes the examination of 35 paintings, of which 26 were examined using a microscope and 9 were examined while hanging on display. Although only 2 early works dating to 1650 and 1655 were examined, 14 belonged to the Delft mid-career period, 11 to the Amsterdam mid-career period, and 8 to the late period. The chief means of understanding the ground, underdrawing, and paint layers of artworks was through microscopic examination, and, when available, technical analysis, which included infrared reflectography (IRR), multispectral infrared reflectography (MS-IRR), x-radiography, x-ray reflectance spectroscopy (XRF), cross sections, and scanning electron microscopy/energy dispersive x-ray spectroscopy (SEM-EDS). Of the paintings examined, there were cross sections for only seven paintings (ranging from 1 to 4 cross sections for each painting) and SEM-EDS analysis on cross sections from two paintings. Furthermore, of these seven paintings with samples, five belong to the Delft mid-career period, one to the Amsterdam mid-career period, and one to the late period. The painting treated during this study, *Woman and Child in a Courtyard*, National Gallery of Art, had by far the most extensive

amount of technical analysis, including MS-IRR, x-radiography, XRF, fiber optics reflectance spectroscopy (FORS), cross sections, SEM-EDS, and pigment scrapings.

Based on the simplicity or minimal use of paint layering, or lack thereof in De Hooch's compositions, it is easy to describe him as a "quick" or "economical" painter. Despite this, his compositions are thoughtful, edited throughout in the form of compositional changes to create a balanced work of art. In gathering information on De Hooch's painting method, it became clear that he used all the tools and techniques available him to create the desired effect: varying the color of the ground, number of ground layers, methods of laying out the composition, and different effects to build up a form. An element of trying to understand De Hooch's technique became looking for consistency—something within the painting methods that might be specific to only the Delft or Amsterdam mid-career period, or to a painting genre, be it courtyard or grand interior.

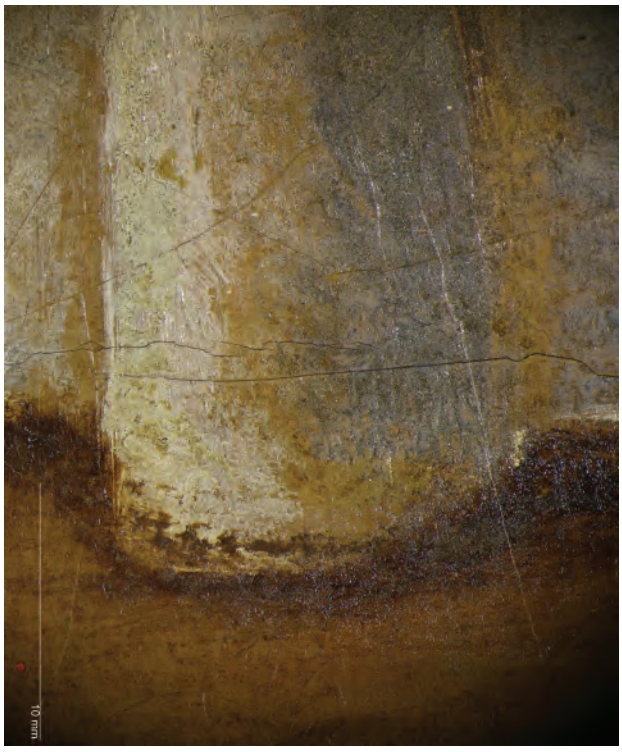
3.1 Support

In-depth study of the canvas characteristics was hindered by limited access to x-radiographs, the fact that many of the paintings were lined, and varied paint thickness; however, a few generalizations can be made: the majority of paintings included in this study are on canvas, which tends to be finely woven with a tight, plain, irregular weave. Only four paintings are on panel, of which, one dates to the early period (1650), and the other three date to the mid-career period (of these three, two date to the Delft period—1657—and one dates within the Amsterdam period—1665). At this point in time, it doesn't seem possible to make major conclusions or correlations between the choice of panel vs. canvas.

3.2 Ground

Throughout De Hooch's paintings, regardless of the period created, the ground layer plays an integral role in the execution of the composition, buildup of paint, and modeling of color. The ground is often left exposed, clearly visible between objects, or it acts as a highlight, midtone, or shadow in the creation of form, which explains why the ground color influences the overall tonal quality of a painting.[2] An example of this can be seen in *Woman and Child in a Courtyard* in the NGA's collection, where the ground is clearly visible in the folds of the child's skirt, as a warm shadow (figs. 1a, 1b). In many cases, especially in backgrounds of interior scenes, such as those with wood ceilings, the paint is only thinly applied on top of the ground in semi-transparent passages, allowing the color below to come through.

1a



1b

Figures 1a, 1b. *Woman and a Child in a Courtyard* and photomicrograph (bottom of child's skirt), ca. 1658–1660, oil on canvas, National Gallery of Art, Washington, DC (Courtesy of National Gallery of Art, Washington)

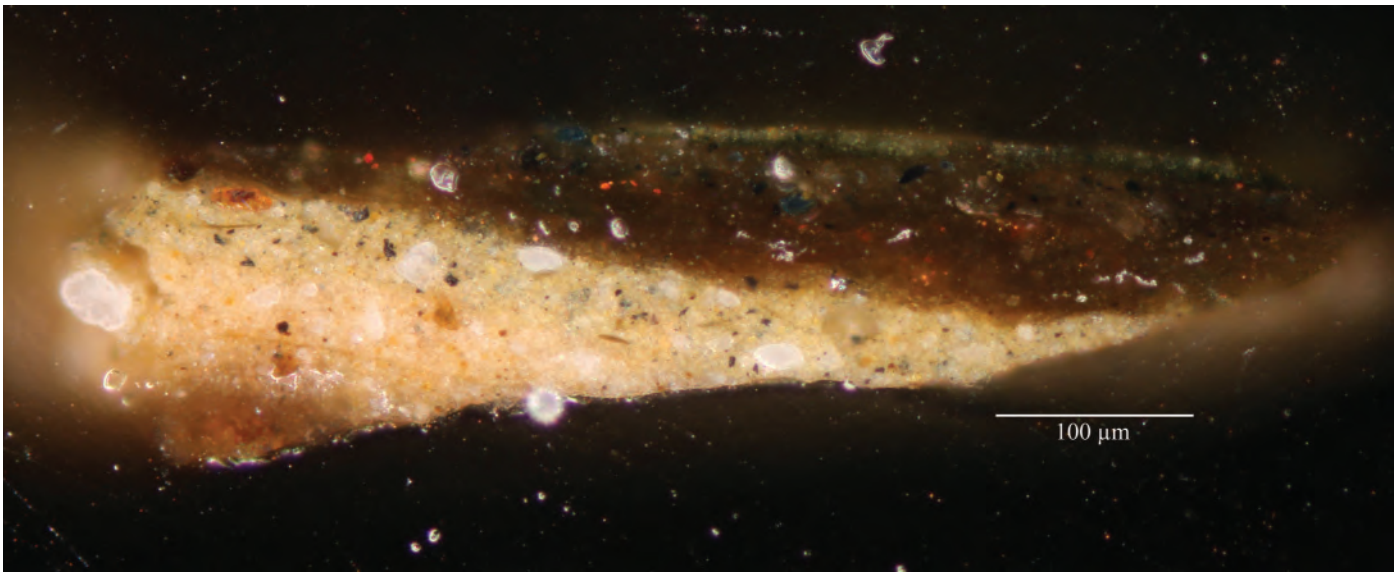


Figure 2. Cross section from *Woman and a Child in a Courtyard*; sample location—a green leaf on the tree on the right side of the composition (Courtesy of National Gallery of Art, Washington)

De Hooch used a number of different colored grounds throughout his artistic career, including tan, gray, red, brown, white, and, in one anomaly, orange. Of these colors, only tan, gray, and red grounds are used for the uppermost ground layer. In some cases, when comparing the quality of a color, such as two different gray grounds, the color varied, with one gray ground containing brown earth pigments, giving it a warmer hue.

Although it was impossible to determine the number of ground layers on every painting due to the limitations of conducting only microscopic examinations, single, double, and even three layered grounds were identified on some artworks. A double ground was identified on 13 paintings; the two layers were detected though visual examination and/or with the aid of cross sections. In addition, more than two ground layers were identified on two paintings (both of these paintings are on canvas): the NGA's *Woman and Child in a Courtyard*, 1658/60, dating to the Delft period and *Couple with a Parrot*, 1675/77, Wallraf-Richartz-Museum, dating to the late period.

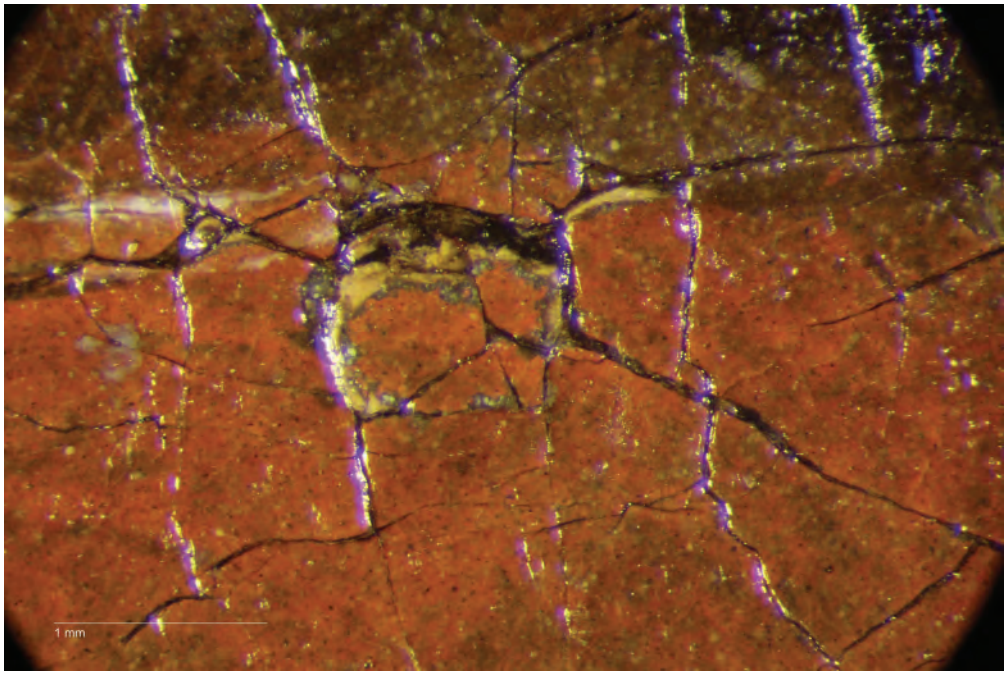
Of the 14 paintings that date to the Delft period, the color of the uppermost ground layer was identified on 13 paintings: six tan, six gray, and one red; this demonstrates a general preference for tan and gray grounds, frequently in courtyard scenes (see table 1). A cross section from *Woman and Child in a Courtyard* (fig. 2), illustrates the use of the cool-tan upper-ground layer, while on *The Bedroom*, in an area of damage (figs. 3a, 3b), the gray upper-ground layer is visible. In terms of ground layering, one painting has a single ground, eight have a double ground, one has three preparatory layers (NGA's *Woman and Child in a Courtyard*), and the number of layers on four is unknown (see table 2). In addition, all the paintings in which a double ground was identified date to 1657–1658.

There are two cases of repeated compositions within De Hooch's oeuvre, and in comparing the ground layering of the NGA's *The Bedroom* and Karlsruhe's *In the Bedroom*, a double ground was identified on each, but the layering appears different: the NGA's painting has a light tan-beige bottom layer with a gray upper layer, while the painting in Karlsruhe has a white bottom layer with a tan upper layer. The ground layering for the other repeated compositions, the NGA's *A Dutch Courtyard* and the Mauritshuis's *A Man Smoking and a Woman Drinking in a Courtyard*, seem to be more similar than the previous example: both are painted on a thin, light, warm-gray layer.[3]

Some similarities exist between the color combinations of the identified double grounds from the Delft period: of the paintings with double grounds, four paintings have a gray upper-ground layer and a lower light beige/tan ground layer, possibly signifying a preference for this color combination. Three of these paintings are interior scenes, while one is a courtyard. An example of this layering structure is on the NGA's *The Bedroom* (figs. 3a, 3b).

Of the 11 paintings from the Amsterdam period, the uppermost ground layer was identified as follows: five paintings have

3a



3b

Figures 3a, 3b. *The Bedroom* and photomicrograph; image location—an area of damage near the center of the tiles in the foreground; ca. 1658–1660, oil on canvas, National Gallery of Art, Washington, DC (Courtesy of National Gallery of Art, Washington)

Table 1. Color of the Uppermost Ground Layers Identified in the Mid-Career Period Paintings

Uppermost Ground Color	Tan	Gray	Red	Brown
Delft	6	6	1	–
Amsterdam	2	5	3	1

Table 2. Number Ground Layers Identified in the Mid-Career Period Paintings

Number of Ground Layers	Single	Double	Triple	Unknown
Delft	1	8	1	4
Amsterdam	–	5	–	6

gray grounds, three red, two tan, and one brown (see table 1). The use of a brown ground as either an upper or lower layer is characteristic of the Amsterdam period. Of these paintings, a double ground was identified on five (see table 2). During the Amsterdam mid-career period tan grounds are used less frequently, and gray upper-ground layers become more commonplace. The Rijksmuseum's *Figures in a Courtyard Behind a House* is an example of a painting from this period in which a gray upper-ground layer was used and is easily visible throughout the composition (figs. 4a, 4b). In addition, a cross section from this painting illustrates that the layering structure of the ground is characteristic of the Amsterdam period, with not only a gray upper-ground layer but a brown bottom-ground layer as well (fig. 4c).

Further into the late period, darker colored grounds are used more frequently, and when reviewing the color combinations of the identified double grounds, darker colors such as red or brown are used more often for the bottommost layer. In addition, the color combination of a gray (top) and red (bottom) double ground was identified on two paintings, but their subjects are different: *Interior with a Young Couple*, 1662, The Metropolitan Museum of Art (The Met), and *Society Playing in Noble Hall*, 1666, Museum der bildenden Künste Leipzig.[4] Last, of the paintings examined, only one brown upper-ground layer was identified on *A Couple Playing Cards, with a Serving Woman*, although this painting has an approximate date: ca. 1665–1775, placing it in either the Amsterdam mid-career period or late period.

Into De Hooch's late period, the overall tonal quality of his paintings becomes much darker, especially the backgrounds, and this may be attributed to the ground color. Despite De Hooch's more frequent use of darker colored grounds, such as reds and browns, in the early 1660s, these paintings still appear luminous, as in *Learning to Walk*, Museum der bildenden Künste Leipzig.

When comparing the use of different ground colors and the subjects of paintings between the Delft and Amsterdam period, some minor correlations can be made: In the Delft period, interior household paintings tend to be on gray grounds, while during the Amsterdam period, when the use of red grounds for this particular subject becomes common place, they tend to be on either red or gray grounds. In addition, most of the courtyard scenes from the Delft period have either a tan or gray colored upper-ground layer, while the only courtyard scene that dates to the Amsterdam period, *Figures in a Courtyard behind a* House, 1663, Rijksmuseum, has a gray upper-ground layer.

Last, as seen in figure 2, the three preparatory layers of the NGA's *Woman and Child in a Courtyard*, were identified in a cross section. At the very bottom, there is an oil and chalk preparatory layer, followed by two earth-toned warm-tan layers, and then a cooler tan layer that contains numerous small black pigments. It is possible that this was a prepared canvas, the use of which was a common practice in the 17th century (Butterworth 170, 166). De Hooch may have only applied the top cooler tan layer to the pre-prepared tan layers below. This particular ground composition and layering is similar to other cross sections examined. Further investigation into this possibility is necessary.

3.3 Preliminary Design

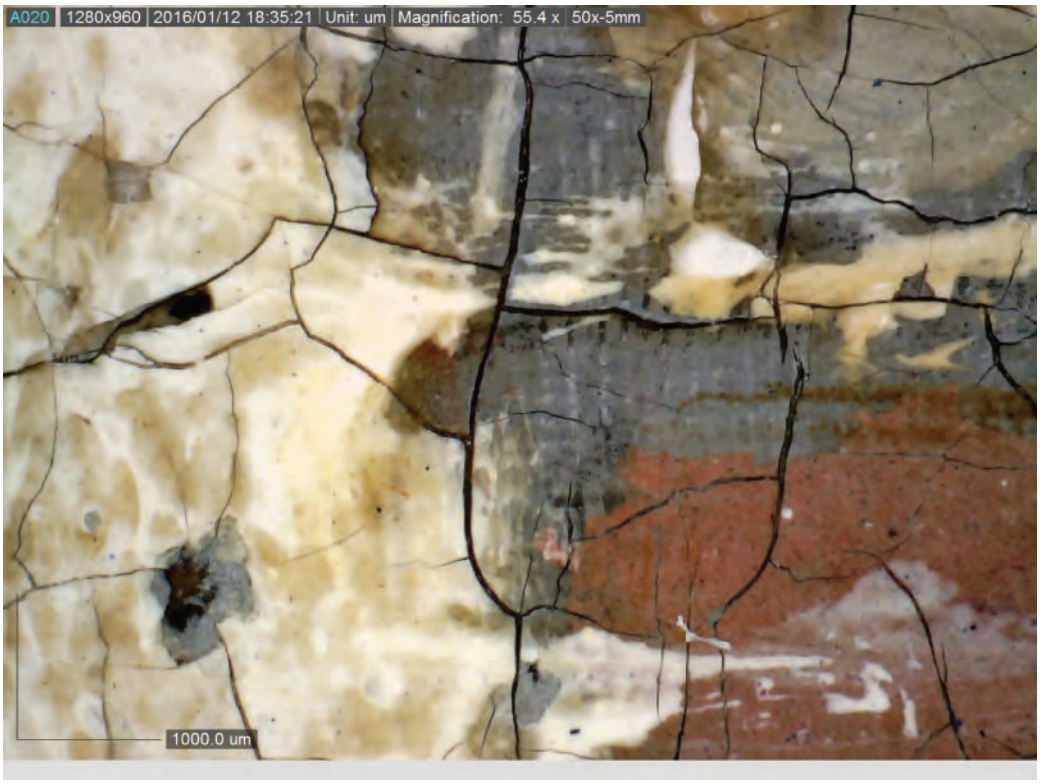
The elements of De Hooch's compositions—the figures, objects, and architectural structures—are precisely placed, appearing deliberate and planned, which is evidenced by his thoughtful use of the ground throughout and by the tendency for objects within the composition not to overlap. A large

4a

Figures 4a, 4b, 4c. *Figures in a Courtyard Behind a House*, photomicrograph (image location—along the edge of the bottom right corner of the roof) and cross section (cross section location—bottom edge, near the bottom right corner) 1663, Rijksmuseum, Amsterdam (Courtesy of Rijksmuseum, Amsterdam; N. de Keyser, Rijksmuseum, Amsterdam; S. Smelt, Paint Sample Database, Rijksmuseum, Amsterdam)

component of this study became an effort to understand how De Hooch planned the placement of objects within the composition, which was challenging at times for many of the paintings. However, it became clear that throughout his mid-career period, De Hooch used a number of techniques and often the use of a particular technique was specific to one type of compositional elements.

The techniques identified include: sketch with a dry media, blocking-out form with a thin semi-transparent earth-toned medium-rich paint, painted line using dark-brown or black medium-rich paint (similar in color to that used for blocking-out form), incised lines, tool marks, and pinholes for perspective lines. Generally, these materials are applied directly to the ground layer.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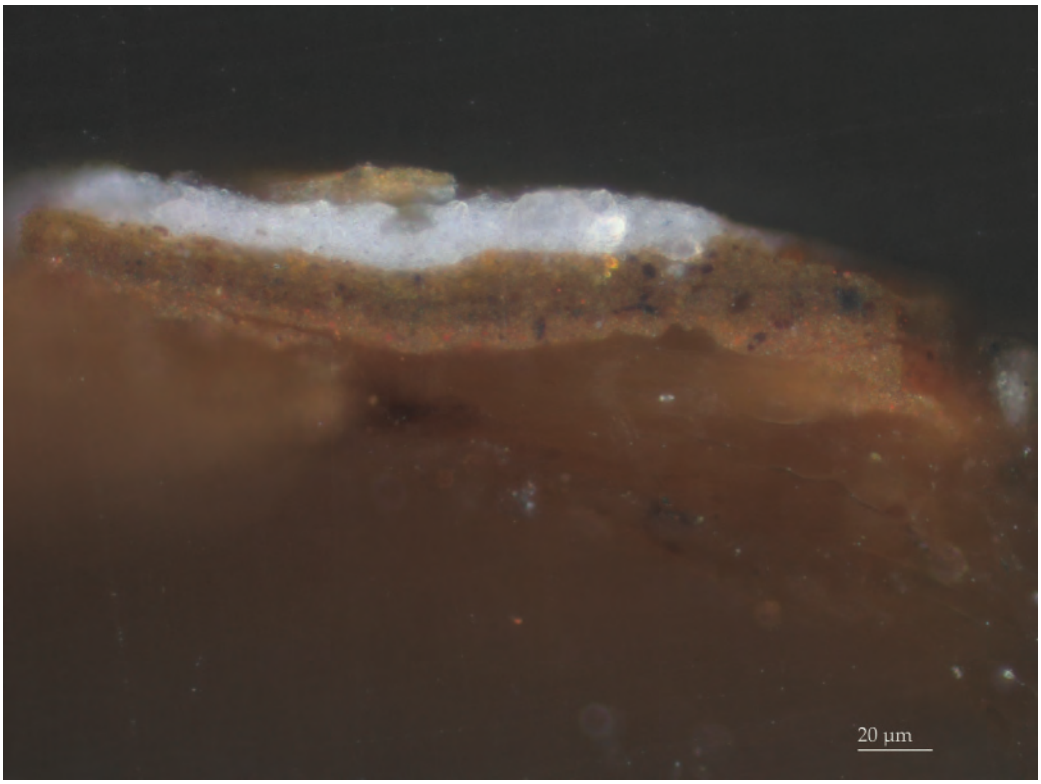
4b


20 µm

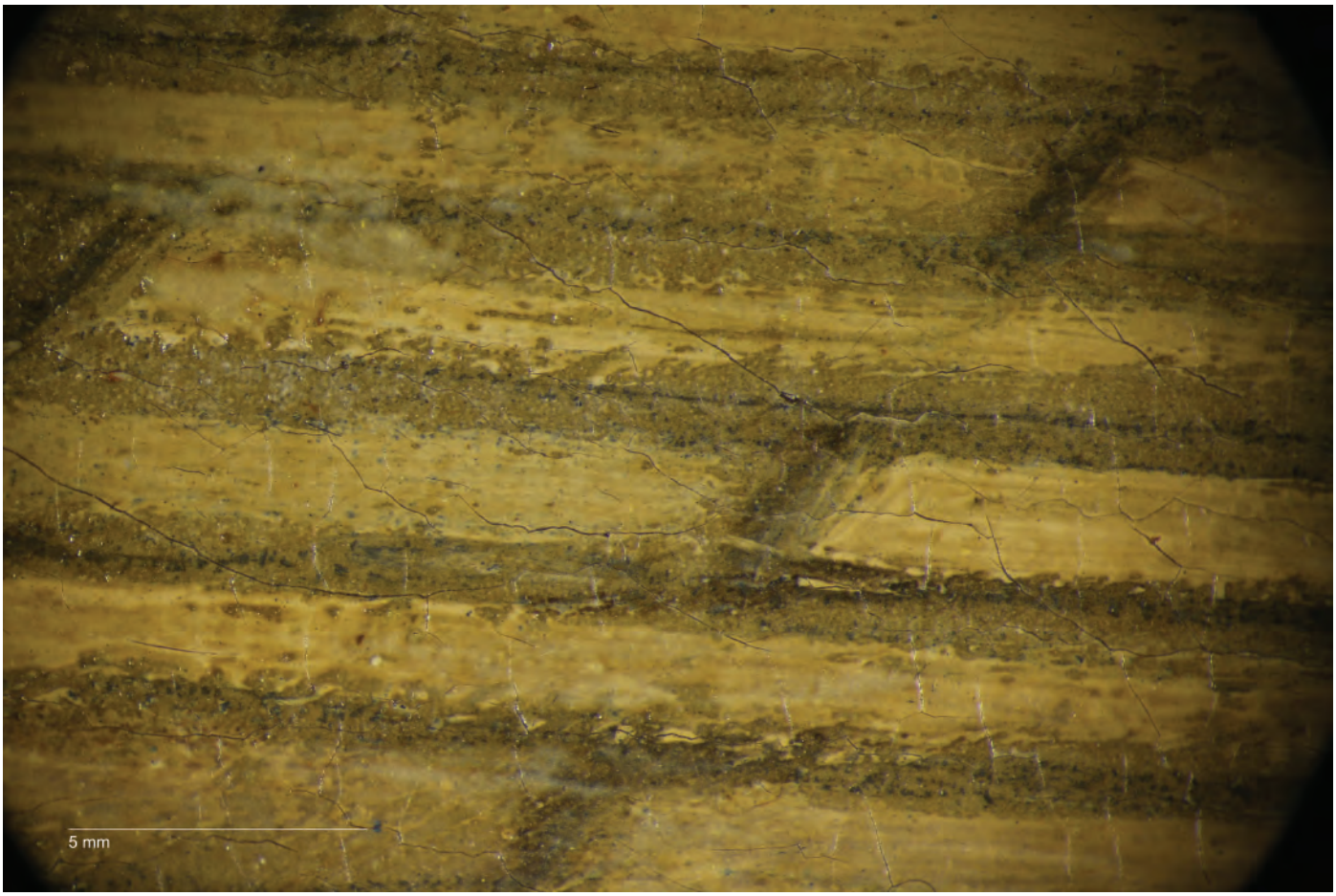
4c

3.3.1 Dry Media

The use of a dry media was identified on six paintings and was used for blocking out elements of the foreground, such as the cobblestone in courtyard paintings, or architectural elements such as doorways and wooden beams in interior scenes. In addition, on one interior scene, a dry medium was used to block-out the tiled floor. On paintings where dry media was used for architectural elements, long horizontal and vertical lines often appear ruled, whereas on other paintings, a dry medium was used freehand for drawing decorative elements. This can be seen in figure 5a and 5b on the NGA's *A Dutch Courtyard*, where dry media is visible along the stones in the foreground in the form of continuous horizontal lines and diagonal strokes; dry media was also used to sketch bricks on the side of the house on the right side of the composition. Under magnification, the dry media appears dark gray in color

5a

Figures 5a, 5b. *A Dutch Courtyard* and photomicrograph; image location—center of foreground, just below black show of seated man on left; ca. 1658–1660, oil on canvas, National Gallery of Art, Washington, DC (Courtesy of National Gallery of Art, Washington)



5b

and metallic. It was not possible to analyze the material for this study but paper conservators at the NGA were consulted and it was generally agreed that the material greatly resembled black chalk or graphite.

There are few instances where dry media was identified in IRR, including Leipzig's *Society Playing in Noble Hall*, 1666, in which a sketch for the ornamental designs on the back wall is visible. In addition, drawn ruled horizontal and vertical lines within the architectural space are also apparent, as well as rounded drawn lines in the archways, where likely a compass was used.

In all cases where identified, the dry media is applied directly on top of the ground, and generally, De Hooch did not bother hiding these lines. They are often left visible, appearing as a dark gray line, and act as a shadow or help to define a form, as is the case with the foreground in the courtyard painting described earlier. It is often difficult to determine the extent that dry media was used, as it is easily picked up and moved around with paint, and in some cases the line is not continuous but rather skips over the texture of brushwork or the canvas weave below.

On the Rijksmuseum's *Figures in a Courtyard Behind a House*, 1663, drawn lines are easily visible throughout the composition with the aid of magnification; these lines appeared ruled and are in the structure of the house—the columns, roof, and bricks. The extent that dry media was used on this painting in notable, whereas on other paintings, the observable use of a dry media is minimal (It is unknown whether this is due to lack of use or by how much the dry media is covered up during the painting process).

3.3.2 Blocking Out

A common thread among many of the paintings examined for the study is De Hooch's use of blocking-out or underpainting forms with a monochromatic layer, usually a semi-transparent medium-rich mixture. The color varies from painting to painting, and can be brown, brown-black, yellow-brown, earth red-brown, or tan. Often the effect of transparency and the tone of the color are based on the thickness of application.

Figure 6. Photomicrograph from *Woman and a Child in a Courtyard*; image location—the proper left arm and sleeve of the standing female figure (Courtesy of National Gallery of Art, Washington)

For example in the woman's shirt and sleeve in the NGA's *Woman and Child in a Courtyard*, a thin brown semi-transparent layer was laid down, and then on top, thicker strokes of the same color were used to create the general folds in her shirt and sleeves (fig. 6). As with this example, the blocking-out layer was often more than just a means of indicating the broad shapes/position of objects; it was integral to the final composition, and is the transparent layer seen along the edges of figures, in the shadows of objects, surrounding/under feet, in the folds of clothing, in between fingers, and such.

In the NGA's *A Dutch Courtyard*, the blocking-out layer is easily visible throughout, especially in the thinly applied paint layers in the folds of the seated man's gray draped cloak, the leg of the other seated male figure, as well as in the child's clothing (figs. 7 and 8). In these examples, the blocking-out layer is a thinly applied semi-transparent medium-rich earth brown layer. The color difference between the first two examples—the lighter color visible at intersections of paint in the gray cloak versus the darker color of the brown pants of the other

Figure 7. Detail of *A Dutch Courtyard* (Courtesy of National Gallery of Art, Washington)

seated male figure (fig. 7)—is due to thickness of application. Within many paintings, the majority of the blocking-out layer functions as a midtone, as with the man's cloak, and in some cases, it plays a larger role in the final composition, as with the other seated male figure's pant leg.

De Hooch also blocks-out aspects of his compositions on a larger scale. For example in the NGA's *A Dutch Courtyard*, a yellow-brown medium-rich layer was used to block out the architecture (house/walls), and, to some extent, this layer extends slightly into the courtyard. This color is integral to the final colors of the architecture in the composition. With De Hooch, the color of the preparation layers is a thoughtful choice that affects the final tonality of the composition. For example, a light terracotta colored layer was used to block out the architectural elements, as well as parts of the foreground, in *A Courtyard in Delft at Evening: A Woman Spinning*, Royal Collection Trust, and as a result the overall tonality of this painting is red.[5]

3.3.3 Painted Sketch/Line

The use of a painted sketch, visible in the form of a thin brown-black line, was identified on only 12 paintings, though this form of preliminary design was often painted over and is only identifiable by small wisps of a line along edges of forms. Often this method goes hand in hand with blocking out, and the painted sketch is built up on top of that layer. This can be seen in the NGA's *A Dutch Courtyard* (fig. 8) where the basic shape of the child's hands and the folds of her sleeves were sketched using a black-brown painted line on top of the brown-black monochromatic layer. This type of sketch is visible throughout the painting, and was used to define the shapes of the three figures and their clothing, especially in

Figure 8. Photomicrograph from *A Dutch Courtyard*; image location—the proper left wrist/arm and sleeve of the child (Courtesy of National Gallery of Art, Washington)

shadows of the two male figures (this sketch does not extend under lighter areas such as the leftmost man's white legging, the woman's skirt, or their faces). The black painted sketch is also evident in the thinly painted folds of the man's gray cloak, his feet, and the proper left leg of the seated man facing out; the sketch acts as the shadow in these forms (fig. 7).

More often than not, the painted sketch is used for planning figures and their clothing, although there are a few instances where it is also used for windowpanes (*Man Handing a Letter to a Woman in the Entrance Hall of a House*, 1668, Hamburg). It is possible that there is a greater use of this technique throughout a composition, such as positioning larger shapes/forms, but this type of use was not identified on paintings during the study. In general, the painted sketch appears to be applied freehand rather than traced or ruled.

On two paintings, Leipzig's *Learning to Walk*, and *A Man Delivering a Letter to a Lady*, ca. 1668–1670, Hamburger Kunsthalle, there is clear evidence of the use of a painted ruled line that is earth red and only used for the architectural elements within the composition. On the Hamburg painting, under magnification, the red earth color appears to be a mixture of a red–tan matrix with small dark (likely black) particles present. These red lines follow the vertical and horizontal parts of the form, as well as the rounded curves of the window and its panes (figs. 9a, 9b). This particular technique has a very selective use and has only been identified in background architectural elements, and not in tiled floors.[6]

Sometimes a painted sketch is visible in IRR, such as in *Learning to Walk*, ca. 1665–1670, Museum der bildenden Künste Leipzig, where an adjustment to the shape of the hem line of the child's skirt is visible.[7] Last, it is important to note that De Hooch sometimes used a brown-black line on top of final paint layers to further define or refine a form, and this can be easily confused for a painted sketch.

9a

3.3.4 Pinholes and Incised Lines

De Hooch also uses pinholes and perspective lines, incised lines, and/or tool marks for laying out the preliminary design. Pinholes have been identified on a number of De Hooch's paintings outside of this study, and considering that they're found on paintings throughout his mid-career period, as well as in the late period, it is likely that this is a technique used throughout his entire career (Sutton 1998, 40–42). Using a pin, likely with chalked string attached, De Hooch would place the vanishing points and orthogonal lines to define the architectural space, especially the tiled floors, within a composition. The extent that De hooch reinforced these lines—either with dry media, paint, or incision—is unclear. One full perspective underdrawing has been identified on a painting in a collection in London, while only a few single or partial reinforced lines have been identified on other paintings during this study.

On the NGA's *The Bedroom*, a pinhole was found on the left side of the composition above the chair with the lion head finials, visible in both the paint layer in normal light (under magnification) and the x-radiograph (figs. 3a and 10). While all the diagonals within the composition match up to this pinhole, no painted or drawn lines were found; however, several short

9b

Figures 9a, 9b. *Learning to Walk* and Photomicrograph, ca. 1665–1670, Museum der bildenden Künste Leipzig. (Courtesy Rüdinger Beck and Sybille Reschke, Painting Conservation, Museum der Bildenden Künste Leipzig)

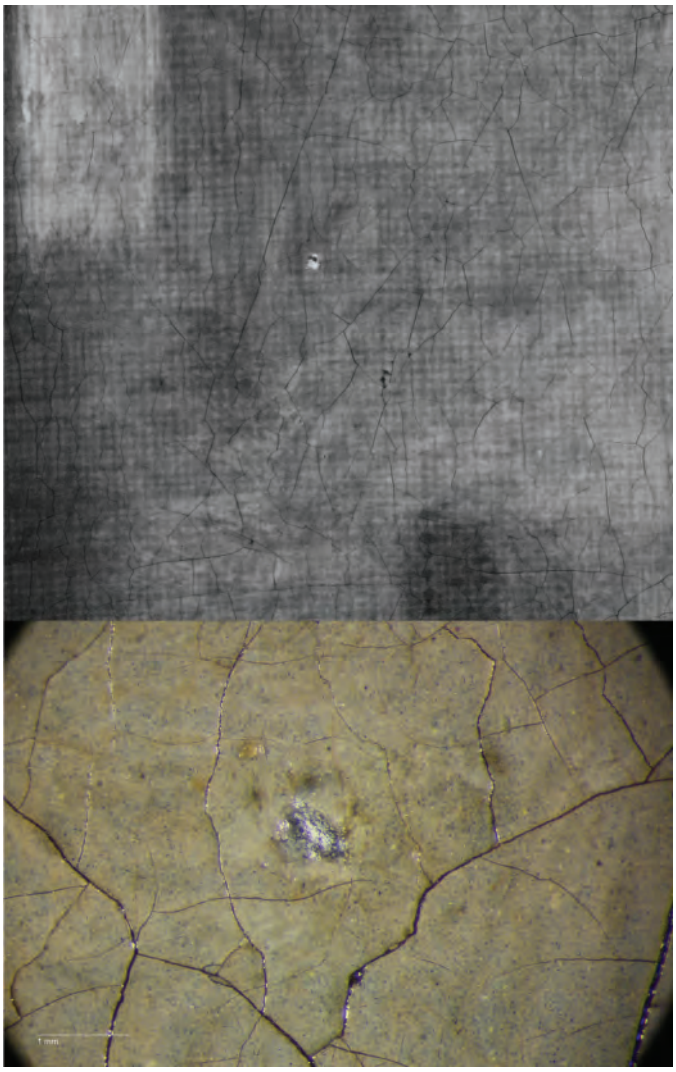


Figure 10. (*Top*) Detail from x-radiograph of *The Bedroom*; (*bottom*) photomicrograph from *The Bedroom* (Courtesy of National Gallery of Art, Washington)

incisions were found throughout the composition [fig. 11: schematic of perspective lines (red) and identified incised lines (blue)]. As mentioned, incisions were identified on a few other paintings during this study: *Woman and Child in a Courtyard*, NGA; *Figures in a Courtyard Behind a House*, Rijksmuseum; *A Woman and Two Men in an Arbor*, The Met. Some of the incised lines follow specific orthogonals, but these lines are often very short, don't follow the full length of the painted form, or aren't the exact same angle as the painted line. They seem to act as only a partial reference for the direction and placement of a compositional element. Similarly, on the two Courtyard paintings in the NGA's collection, there are short incised lines that don't necessarily follow an orthogonal or architectural element, but which seem to indicate the placement of a form,

Figure 11. Schematic of perspective lines (*red*) and identified incised lines (*blue*) on *The Bedroom* (Courtesy of National Gallery of Art, Washington)

such as those seen in figure 11 in *The Bedroom*, near the child's ankles and the chair to the right of the doorway. It is possible that when De Hooch reinforced lines, either by incision, dry media, or paint, only a few reference lines were judiciously chosen.

4. PAINT LAYERS

In general, De Hooch paints thinly, and forms are built up from back to front, leaving reserves (i.e., blocking-out form in the thin monochromatic paint layer) for nearer or important forms. De Hooch also paints economically, with minimal paint layering or modeling, and often, the form is built up in one layer, with varying shades laid down side by side, ever so slightly blended into one another. When paint is built up in layers, it is generally applied wet over dry, and it is very likely that the layer below is easily visible.

Because De Hooch puts so much time and thought into laying out the preliminary design of his paintings, either through blocking out, painted sketch, the use of dry media and/or paint, pinholes, perspective lines, and incisions, he is able to precisely place color to build forms, knowing where figures and objects are positioned.

The degree of finish or the amount of paint layering varies greatly from painting to painting and this quality can also vary

12a

12b

Figures 12a, 12b. *Woman with a Child in a Pantry* and photomicrograph; image location—woman's face; 1656, Rijksmuseum, Amsterdam (Courtesy Rijksmuseum, Amsterdam)

greatly within a single painting. For example, in the Rijksmuseum's *Woman and Child in a Pantry*, the face of the woman is quite finished, with modeled paint, whereas the background (ceiling and left-most wall) and even the sleeves of the woman are much looser and appear to be painted quickly (figs. 12a, 12b). When comparing the face of the woman in the Rijksmuseum's painting to the face of the man in the NGA's *A Dutch Courtyard*, the quickness and economy in painting the latter is easily visible: the tan ground serves as the cool shadows, contrasting with the warm peach tones (fig.13). As seen in these examples, paint within a single layer is often modeled wet-in-wet, with slightly varying tones laid side by side without a great deal of blending.

When comparing two paintings of the same composition such as the NGA's *The Bedroom* and Karlsruhe's *In the Bedroom*, the difference in both brush handling and palette in areas such as the garden (visible through the open door) is notable. In Karlrsuhe's painting, the shrubbery is much greener and flowers are represented by bright pink, yellow, and orange round dabs of paint; the effect of sunlight is much stronger in this painting, due to both the colors used and the thickness/size of the paint stroke. Although Karlsruhe's painting is covered in a discolored varnish layer, the thickness of the highlighting brush strokes on the fence rails, as well as the

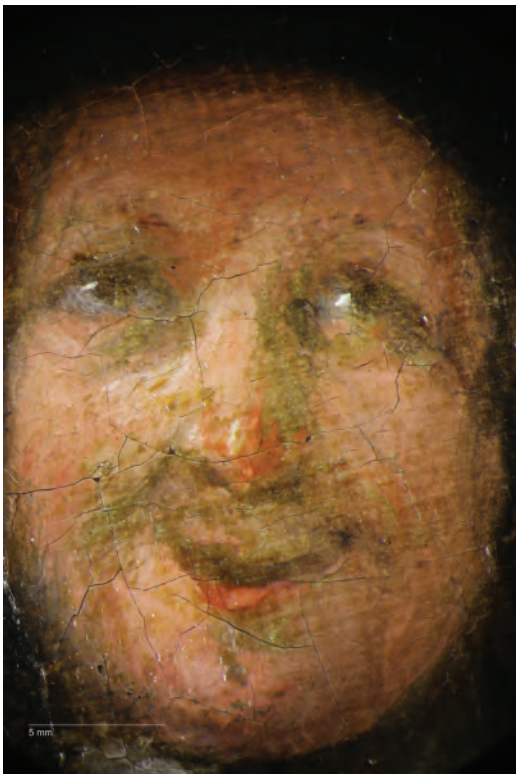


Figure 13. Photomicrograph from *A Dutch Courtyard* (Courtesy of National Gallery of Art, Washington)

color palette are certainly more luminous and colorful than the NGA's painting. In the latter, the details of the shrubbery are represented by small flicks of mainly cool tones of greens and blues, and only includes a few warm yellow touches.

4.1 Painted Effects and Tool Marks

In his body of work, De Hooch's frequently uses very thin layers of transparent or semi-transparent medium-rich paint to create certain effects, such as the sunlight reflecting off an open door in the Rijksmuseum's *Woman and Child in a Pantry*: just a thin scumble of warm yellow-brown medium-rich paint achieves this effect (fig. 12a). This can also be seen on tiled floors, where thin scumbles of paint are used to create stains or dirt.

Throughout his career, De Hooch focused on the quality of light and the transition between cool and warm tones; great care was taken in modeling the colors as shadow turns to light. The warm medium-rich earth tones he uses in shadows are bordered by cool blues, such as those seen on the right side of the child's bodice in the NGA's *The Bedroom* (fig. 14) or the small cool blue stroke that creates reflected light in the shadow of the child's foot. De Hooch creates this effect with just the smallest touches of paint.

While incisions and tool marks were found on a number of De Hooch's paintings as part of the planning phase of the composition, they were also used for creating a final effect, and found on a few paintings dating to both the mid-career period in Delft and Amsterdam. An example of this can be seen in The Met's *A Couple Playing Cards with a Serving Woman*, where, instead of paint, a tool was used to delineate the different cards held by the seated female figure (figs. 15a, 15b). Another example is in the NGA's *A Dutch Courtyard*, where thin-tooled lines are visible in between the woman's red skirt and the seated man's leg, delineating the cobblestones.

Final highlights are usually painted on top of a dry layer, and are thoughtfully placed small dabs of paint. Often, pure colors such as lead white or lead tin yellow, are used. It is also common for

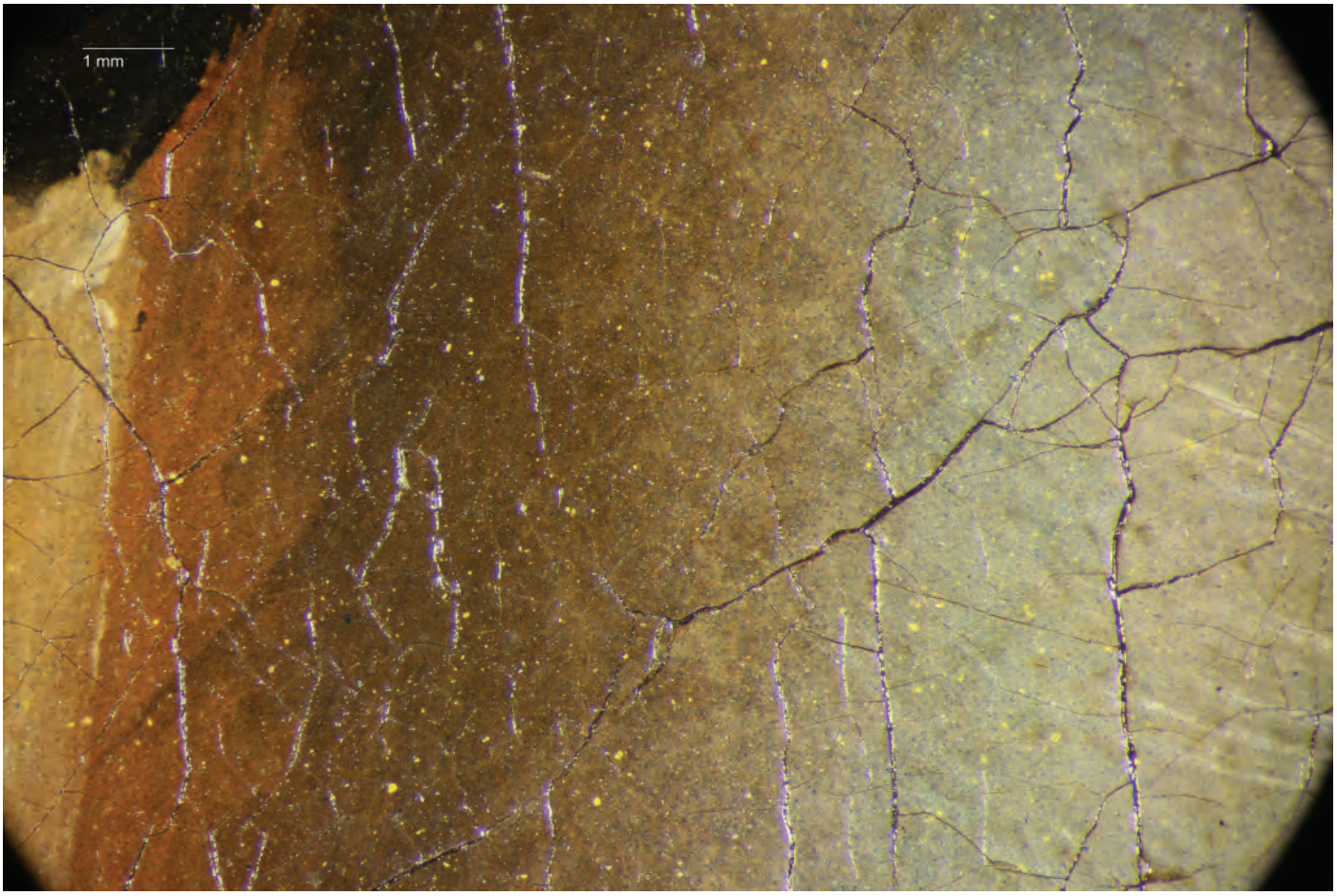
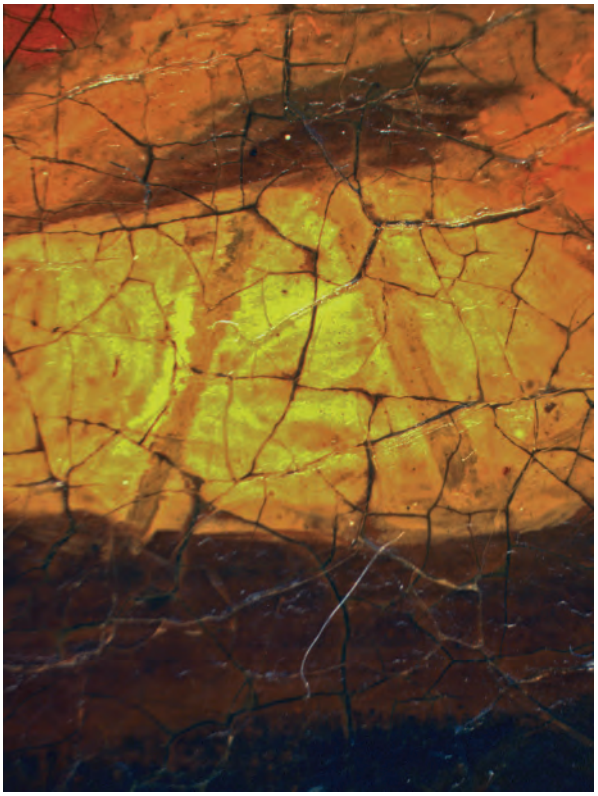


Figure 14. Photomicrograph from *The Bedroom*; image location—torso of child (Courtesy of National Gallery of Art, Washington)

15a



15b

Figures 15a, 15b. *A Couple Playing Cards with a Serving Woman* and photomicrograph; image location—cards seated woman is holding; ca. 1665–1675, The Metropolitan Museum of Art, NYC (Courtesy of The Metropolitan Museum of Art, www.metmuseum.org)

De Hooch to paint a few colors, either layering them or placing them side by side to build up a highlighted effect, as seen in the leg of the table in the NGA's *The Bedroom* (fig. 16).

Reticulated paint was identified on five paintings included in the study: three from the Delft mid-career period and two from the Amsterdam mid-career period. From examination of these areas, it seems less likely that these paintings were damaged by a past treatment or that the reticulation is due to paint degradation, but rather the result of De Hooch's application of a medium-rich paint mixture that beaded up on the dry layer below (fig. 17). It must have occurred at the time of paint application and was retained for the effect it created. For example, reticulated paint identified in courtyard paintings creates the effect of dirt or fallen leaves, while in interior scenes it appears as either dirt on the tiled floor or part of a shadow.

4.1.1 Pentimenti

Both minor pentimenti—adjustments to the positioning of hands, heads, or the size and shape of clothing—as well as larger pentimenti—painting out a figure or architectural element—are prevalent throughout De Hooch's career. These larger pentimenti were found on three paintings from the Delft mid-career period and two paintings from the Amsterdam mid-career period. On the NGA's *Woman and Child in a Courtyard*, extensive changes were made to the architectural elements within the composition (fig. 1a). In normal light on the left side of the composition, one can see that a second structure was painted behind the house but the multispectral infrared reflectogram (MS-IRR) rendered in color reveals more (fig. 18).[8] The details of the roof suggest that the building is likely the Oude Kerk in Delft, which De Hooch painted in other compositions from this period (such as in the NGA's *A Dutch Courtyard*). In addition, as seen in the MS-IRR, the Delft Wall is extended further to the left, in front of the original positioning of the church, and the trellis on the house was painted to the same height as the red earth-toned wooden gate to its right. To the right of the arbor, a garden house with a red tiled roof was painted out, covered with the tan color used to paint the wall of Delft. The top edge of the red roof wasn't completely convered and can still be seen slightly extending into the trees above the

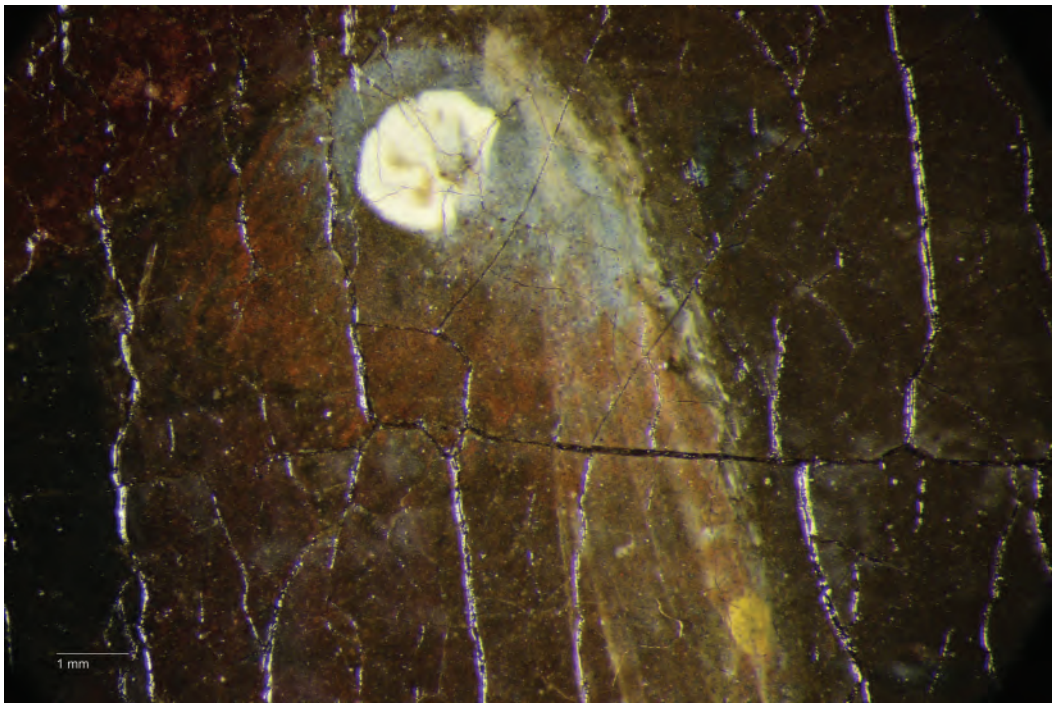


Figure 16. Photomicrograph from *The Bedroom*; image location—highlight on leg of table on right side of composition (Courtesy of National Gallery of Art, Washington)

Figure 17. Photomicrograph from *Woman with a Child in a Pantry* (*near bottom left corner*) (Courtesy of Rijksmuseum, Amsterdam)

Figure 18. Multispectral infrared reflectogram rendered in color of *Woman and a Child in a Courtyard*; composite of three registered sets of false-color spectral images, in wavelength bands 1100–1400 nm (*blue*), 1500–1800 nm (*green*), and 2100–2400 nm (*red*) (Courtesy of John Delaney, Kate Dooley, and Giorgio Trumpy, Scientific Department, National Gallery of Art, Washington)

Delft wall. Had this garden house remained in the composition, the setting would have been extremely similar to the background of *A Woman and her Maid in a Courtyard* in the collection of The National Gallery, London, which also features the same arbor with figures sitting inside and garden house. The compositions of these two paintings were clearly based on the same setting. These major changes that De Hooch made to the composition of the NGA's *Woman and Child in a Courtyard* creates a more enclosed intimate space for the figures.

CONCLUSIONS AND FURTHER RESEARCH

This study on De Hooch's technique establishes that he used all the tools available to him as a 17th century artist in order to achieve a painted effect. Although there are some differences between the Delft and Amsterdam period—such as the use of different ground colors and layering, or the use of a painted red line for architectural components (specific to the Amsterdam period)—no other major differences appear in his technical practice during the mid-career period.

De Hooch's painting technique is now better understood, but this study is by no means exhaustive. Further study in many of the areas discussed would be beneficial in order to tease out other patterns in De Hooch's technique, for example, in areas such as the support. It would be helpful to examine more paintings on panel and answer questions such as why De Hooch chose to use panel for those few paintings? What are the technical differences between the panel and canvas paintings? Further questions regarding the ground include are there other patterns in De Hooch's choice of ground color and/or layering during the Delft and/or Amsterdam mid-career periods? Is there any significance to the number of ground layers? Is there a possibility De Hooch used prepared canvas with ground layers? If so, did he adjust the color of the prepared ground, by applying his own on top? Further investigation into the use of pinholes, perspective and incised lines would also be valuable. In addition, considering the focus of this study was the mid-career period, further in-depth study of De Hooch's early and late works would shed more light on his technical progression. Last, it would also be helpful to examine all of De Hooch's techniques within the context of his contemporaries, and to consider how much his choices were influenced by other artists. So many high-life genre artists worked in Delft and Amsterdam at the same time as De Hooch; it would be interesting to consider the influence that these artists had on one another.[9]

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NOTES

1. The relationship between De Hooch and Vermeer, as well as other 17th century genre painters, is currently being studied by Melanie Gifford and Lisha Ginsman. Publication forthcoming: E. Melanie Gifford and Lisha Deming Glinsman, "Materials and techniques of high-life genre painting: collective style and personal manner" in exh. cat. *Vermeer and the Masters of Genre Painting: Inspiration and Rivalry* by Adriaan E. Waiboer, Arthur K. Wheelock, Blaise Ducos, and Piet Bakker, 65-83. New Haven, Conn: Yale University Press, 2017.
2. There is one exception to this finding worth mentioning. *The Jacott-Hoppesack Family* in the Amsterdam Collection, dating to 1670—either the very end of the Amsterdam period or beginning of the late period—is one of the few commissioned portrait paintings executed by De Hooch. The degree of finish on this painting is extremely fine compared to other paintings examined for this study. The ground layer was not (easily) identifiable at any object interface or seen used as a highlight, midtone, or shadow.
3. The number of ground layers in the NGA's *A Dutch Courtyard* is unknown (no cross sections were taken from this painting); however, through microscopic examination, it appears that the upper-ground layer is warm gray in color. Cross-section analysis of the Mauritshuis' *A Man Smoking and a Woman Drinking in a Courtyard* shows possibly two grayish ground layers (containing chalk and earth pigments), as well as a thin gray layer on top (likely an imprimatura). This upper gray (imprimatura) layer has a similar composition to the ground layers, and contains lead white, earth pigments, and charcoal black.
4. Around the same time that these double gray and red grounds date to, similar ground color combinations have been identified on paintings by Vermeer in the National Gallery, London, where their two paintings have double grounds with a lower pale gray-brown layer and an upper light pinkish brown layer.
5. This was discovered by Rosanna de Sancha, paintings conservator, while examining paintings by De Hooch in the Royal Collection Trust for the recently upgraded and republished "Catalogue of Dutch Paintings in The Royal Collection." Royal Collection Trust/© Her Majesty Queen Elizabeth II 2016.
6. Often when painting tiled floors, De Hooch painted each individual tile (often alternating colors) but left the ground layer visible in between each tile. He would then paint a dark stroke/line along the bottom or side of a tile for emphasis or shadow. This line is painted on top of a dry layer but can easily be confused for a component of the preliminary design.

7. IRR was conducted by Rüdiger Beck and Sybille Reschke, Museum der bildenden Künste Leipzig.
8. MS-IRR was conducted by John Delaney, Kate Dooley, and Giorgio Trumpy, National Gallery of Art, Washington D.C. It is a composite of three registered sets of false-color spectral images, in wavelength bands 1100–1400 nm (blue), 1500–1800 nm (green), and 2100–2400nm (red).
9. See note 1.

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Experimental Study on Merits of Virtual Cleaning of Paintings with Aged Varnish

ABSTRACT

Aged and discolored varnishes on paintings decrease the brightness of the white, brighten the darks, and give an overall color shift toward yellow. These alterations often cause a loss of 3D appearance. Digital "virtual cleaning" utilizes color images and ad hoc information about the optical properties of the varnish and the painting surface to provide conservators and curators an intuitive feel of how the appearance of the painting will change if the varnish is removed or replaced. Virtual cleaning with more spectral information (e.g., multispectral data) on mock-ups, paints glazed with an artificially aged varnish, or comparing the reflectances of degraded parts of the painting and parts that did not degrade since they were protected (e.g., by the frame) have been attempted to generate more realistic appearance of cleaned paintings. This article reports on further studies to develop a more complete and accurate model that describes how the aged varnish alters the color appearance of a painting. This is done through hyperspectral imaging of paintings undergoing conservation treatment, following the change in reflectance with the varnish removal process and developing a mathematical model that describes the change. We will report on two panel paintings that were followed during their conservation treatment: the first is a small impressionist panel by Georges Seurat entitled Haymakers at Montfermeil*, ca. 1882, and the second is a Dutch still life by Jan van Huysum entitled* Flowers in an Urn*, ca. 1721, both paintings with a large range of colors, exhibiting vibrant pure colors as well as dark passages.*

1. FOREWORD

This study is the outcome of a long collaboration between the National Gallery of Art in Washington DC, the University of Poitiers, and the Institute of Applied Physics "N. Carrara" in Florence. The results found by Trumpy and colleagues have been already published in a scientific journal of the Optical Society in 2015. To disseminate the results between conservators, the findings have been presented as a paper at the annual meeting of the American Institute for Conservation in the Paintings Specialty Group.

2. INTRODUCTION

Aged and discolored varnishes affect the appearance of paintings by shifting colors toward yellow, and obscuring image details due to loss of transparency in the varnish layer and accumulation of dirt (e.g., candle soot and grease).

The possibility to predict the appearance of a painting after removal of an aged varnish ("virtual cleaning") is widely considered a useful and appealing prospect. With the development of new imaging technologies, virtual cleaning has become a possible scenario in recent years. In fact, the ease of manipulating the pixel numbers of a digital image, not only made color reproductions more accurate (Martinez, Cupitt, and Saunders 1993; Baronti et al. 1998; Imai and Berns 1998), but also offered the ability to predict how a painting might look without the effects of degradation phenomena (Cortelazzo, Geremia, and Mian 1995; Barni, Bartolini, and Cappellini 2000; Pappas and Pitas 2000; Berns 2005; Schirripa Spagnolo 2011), as for instance the aging of its varnish.

Such a prediction requires a mathematical model that describes numerically how the presence of an aged varnish affects the appearance of a painting, and the goodness of the prediction is related to how closely the model describes reality.

In recent years, scientists and other scholars attempted virtual cleaning of paintings adopting quite simple models, and their experiments generally lacked a validation of the result because the examined paintings did not undergo "real" varnish removal (Cotte and Dupraz 2006).

The aim of the present study was to test the limits of virtual cleaning, and meanwhile develop a phenomenological model for aged varnishes by directly measuring the changes in diffuse reflectance of Old Master paintings undergoing actual varnish removal.

3. EXPERIMENTAL METHOD

The appearance of a painting, as any other physical object, is determined primarily by how the incident light is reflected back by its surface and reaches an "observer." One of the physical quantities that can measure the appearance is the "reflectance," which is the ratio between the radiances reflected by, and incident on, a surface for each measured wavelength.

The experimental method used for the present study was to measure the diffuse reflectance spectra of paintings before and after the aged varnish was removed with solvents, as well as after application of a fresh varnish.

Two types of reflectance measurements were performed: point-based fiber optics reflectance spectroscopy (FORS) and reflectance imaging spectroscopy (RIS). The FORS spectra, which have an extended spectral range, have been useful to study the optical phenomena associated with aged varnishes extending in the near infrared (from 1000 to 2500 nm). RIS allowed creating the final image product of virtual cleaning, that is, the color accurate image of the clean painting predicted by the model.

4. PHENOMENOLOGICAL MODEL

"Virtual cleaning" is performed with a formula that predicts the reflectances of the clean painting (R_{VC}) from the reflectances of the painting with the aged varnish (R_{UC}). The simplest approach is to consider the aged varnish as a yellow filter that absorbs the short wavelengths of the visible range (the blue light). If T is the transmittance of the varnish layer, for every wavelength λ the reflectance of the clean painting can be calculated with the following formula, resulting from the Beer's law:

$$R_{VC}(\lambda) = \frac{R_{UC}(\lambda)}{T^2(\lambda)} \quad (1)$$

To study in better detail how the diffuse reflectance changes when an aged-varnish is removed and a new varnish is applied, reflectance measurements were carried out on *Still Life* by Willem Kalf (fig. 1). FORS measurements were made on the inner white portion of the delftware bowl. The measurements were made on the same spot and with the same collection geometry before and after aged varnish removal, and after a new varnish (MS2A working varnish) was applied. Comparison of the diffuse reflectance spectra before and after physical cleaning shows an increase in reflectance with the varnish removal over the entire spectral range measured (350–2500 nm) (fig. 1). This increase can be described as the composite

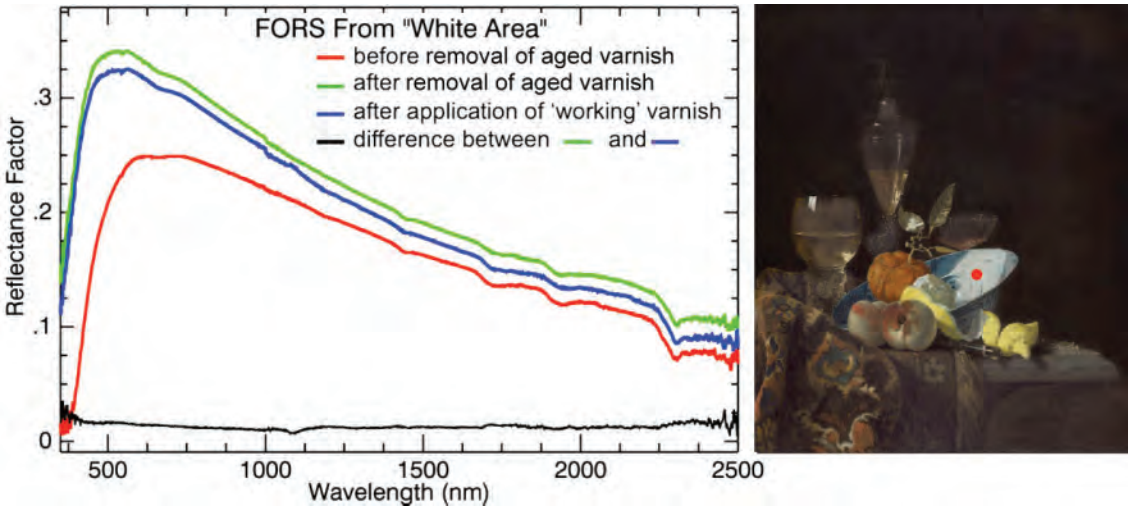

Figure 1. *Still Life* by Willem Kalf, ca. 1660 (National Gallery of Art, Washington DC—Chester Dale collection). The red spot in the color image of the painting (inside the delftware bowl) indicates where the multiple diffuse reflectance measurements were made.

contribution of a constant (*wavelength-independent*) increase (2.5% ca.) in the whole range and a further increase in the visible range that gets gradually stronger (*wavelength-dependent*) approaching the UV/blue region. The wavelength-independent increase can be attributed in part to the uncovering of the rough paint surface, while the wavelength-dependent increase in the visible is mainly associated with the UV/blue absorption by the degradation products in the varnish.

The application of a fresh varnish (MS2A) resulted in a wavelength-independent decrease in the measured diffuse reflectance (1.2% ca.) in the entire spectral range (fig. 1). This is consistent with prior studies of the optical effect of varnishes and resins when applied to paintings (de la Rie 1987, de la Rie et al. 2010), namely the varnish reduces the painting roughness creating a new interface with air that is smoother than the air/paint interface.

These single-point reflectance measurements offer a phenomenological model in which the radiation diffusely reflected by a paint surface can be separated into two different components (Shafer 1985): the reflection that occurs at the interface with air and the *body-reflection* (also called volume-reflection). The first reflection has the same spectral distribution as the incident radiation (wavelength-independent) as it does not interact with the absorbing colored materials (i.e., the pigments). The angular distribution of this interface scattering is dependent on the surface roughness of the illuminated area. The second component comes from the matrix that comprises pigments and binder, where the spectral distribution of the incident radiation is modified due to absorption and scattering by the binder embedded pigment particles.

From the Kubelka–Munk theory (Kubelka 1948), a more rigorous model has been derived (Trumpy et al. 2015) that takes into account the variables playing an important role in painting/varnish system: the reflectance of the painting before cleaning (R_{UC}), the reflectance and the transmittance of the aged varnish (R_V, T), and the interface reflection of the bare painting (R_P). The model is expressed by the following formula:

$$R_{VC}(\lambda) = \frac{R_{UC}(\lambda) - R_V}{T^2(\lambda) + R_V(R_{UC}(\lambda) - R_V)} + R_P \qquad (2)$$

5. CASE STUDIES

Two panel paintings with a large range of colors were selected as case studies (Trumpy et al. 2015). The first is a small impressionist panel, *Haymakers at Montfermeil*, by Georges Seurat that had a thick yellow varnish. At the end of the conservation treatment, the painting was left unvarnished, since Seurat despised varnish in his paintings (Herbert and Seurat 1991). The second is a still life by Jan van Huysum, *Flowers in an Urn*, with a smoother and glossier paint surface, whose conservation treatment included the aged varnish removal and the final re-varnishing.

Hyperspectral images of the two paintings were collected before the conservation treatment. Afterwards, point-based diffuse reflectance from a light and a dark site of the paintings were collected before and after preliminary local cleaning tests. Assuming the dark site completely absorbs the incident radiation penetrating the interface, the measurements of the dark site before and after cleaning are a good estimation of R_V and $R_{P,}$ respectively (Nobbs 1985).

The other important actor in the model (eq. 2) is the transmittance of the varnish layer T, which can be now determined for the "white" point using its diffuse reflectance measurements before and after local cleaning. Thus, all the variables in equation 2 are determined from two point-based diffuse reflectance measurements, and the hyperspectral cube acquired before cleaning can be now processed. This process put the virtual cleaning into practice, predicting all the reflectances of the painting without the aged varnish, assuming that the parameters derived from the diffuse reflectances of the two measured points can be applied to the whole painting.

Colorimetric calculations were carried out on the hyperspectral cubes to obtain the CIE XYZ tristimulus values, using the standard illuminant D65 and the 1964 supplementary standard colorimetric observer (CIE 2006). The coordinates in the CIELAB color space (whose perceptual uniformity is sufficient for our purposes) were calculated from the tristimulus values (CIE 2007), and color differences were expressed with Euclidean distances ΔE.

After the conservation treatment, a new hyperspectral cube was acquired (R_C), and the comparison between the colorimetric values of the painting after virtual and real cleaning allowed to judge numerically the degree of success of virtual cleaning. To this aim, the pixel-by-pixel image registration of the two hyperspectral cubes was necessary; this process was done using a novel point-based registration algorithm (Conover, Delaney, and Loew 2015) that achieves registration with a maximum error of ⅓ pixel.

6. RESULTS

In this article, only the colorimetric results are reported. For a viewing of the color images and a thorough analysis of the spectral data, please refer to the open-access publication in the *Optics Express* journal (Trumpy et al. 2015).

Reflectance imaging spectroscopy (RIS) was carried out on Seurat's *Haymakers at Montfermeil* before and after the physical removal of aged varnish and grime. The ΔE between the colorimetric values derived from the RIS measurements before (R_{UC}) and after (R_C) physical cleaning is a measure of how much the aged varnish affected the color appearance of the painting. The average value of this colorimetric difference over the painting was 8.3 with a standard deviation of 2.0, indicating a large perceivable color change.

On the other hand, the ΔE between the colorimetric values after actual and virtual cleaning represents a metric for the degree of success of the virtual cleaning. The average value of this colorimetric difference over the painting was 3.1, with a standard deviation of 1.5. This residual colorimetric distance indicates a difference that, still perceptible by eye, is quite small.

The experimental study of the *Flowers in an Urn* by Van Huysum focused on the central part of the painting, where the large range of saturated colors is concentrated. The average ΔE across the analyzed region before and after actual varnish removal (i.e., the color change due to the treatment that left the painting unvarnished) was 10.7 with a standard deviation of 4.7.

After virtual cleaning, the residual average ΔE was 4.2 with a standard deviation of 1.9, indicating a perceivable color difference between the predicted and measured images of the painting without varnish.

The analysis of the predicted R_{VC} and measured reflectance R_C of the Dutch still life (Trumpy et al. 2015) suggests a significant spatial variability in varnish transmission and painting roughness, indicating that a procedure that assumes constant parameters across the painting is not always effective. Actually, the type of pigment and the size of its particle influence the surface roughness of the paint layers. As a consequence, the air–painting interface scattering R_p may vary considerably across the painting following the distribution of the pigments. A layer of fresh varnish, besides making the painting smoother, makes the residual roughness more homogeneous, and this should result in an interface scattering with a lower spatial variability.

7. CONCLUSION

This work presented a phenomenological model for aged varnishes on paintings that includes the varnish transmission function and scattering terms, which can be used to put virtual cleaning into practice. The experiments conducted on a small painting by Georges Seurat and a still life by Jan van Huysum, both followed during their conservation treatment, provided satisfactory results with two point-based diffuse reflectance measurements before and after local varnish removal with solvents. However, the necessity to clean a white and a dark point of the painting limits the applicability of the procedure.

The residual color differences between the painting after virtual and actual cleaning are ascribable to spatial variations in the characteristics of the aged varnish (e.g. thickness, local toning, and degradation) and the underlying painting (surface roughness).

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AARON SHUGAR and REBECCA PLOEGER

The Identification of Natural Indian Yellow and Other Historic Late 19th Century Pigments from the Toulouse-Lautrec Estate in France

EXTENDED ABSTRACT

In the late spring of 2015, a unique opportunity presented itself for the collection of a range of samples from late 19th century tin tubes of oil paints from Henri Toulouse Lautrec's childhood home, Château du Bosc, in southern France. These tubes were located in a wooden box with a shipping label to "Monsieur Henri de Toulouse-Lautrec." The pigments came from two artists' suppliers in Paris: Dubus, which was located in the 8th district and sold art supplies from 1877 to 1897 and Leon Berville, which was located in the 9th district and sold art supplies from 1870 to 1895. The pigments identified with polarized light microscopy (PLM), x-ray fluorescence (XRF), μ-transmission Fourier transform infrared spectroscopy (μ-FTIR) and pyrolysis gas chromatography–mass spectrometry (py-GC-MS) were those of a typical palette of the time, including vermilion (manufactured with the dry method), red madder, umbers, and chrome yellow. Two samples of cadmium yellow were identified with XRF and μ-FTIR, and PLM analyses clearly showed evidence of Otavite—a cadmium carbonate that may be linked to the dry manufacturing production process for cadmium yellow, or to a pigment degradation process (Shugar et al. 2016). As well, two tubes labeled "Orange de Zinc", or Zinc Orange, were analyzed with py-GC-MS and found to be triphenylmethane-based orange dyes and not nitroprusside-based as expected according to the Pigment Compendium (Eastaugh et al. 2007). The triphenylmethane group of dyes are poor performing and unstable, much like what is reported for true Zinc Orange pigment, which had a limited window of manufacture and use because of its known instability.

An interesting discovery, which was the main focus of this study, was three samples of authentic Indian Yellow oil paints. More detailed information can be found in a paper recently published in the *Journal of Cultural Heritage* about Indian Yellow (Ploeger and Shugar 2016) but will be summarized here. Indian Yellow is a magnesium or calcium salt of euxanthic acid and is known by several other names including: Puree, Peori and Gogoli, among many others. In the early 20th century, the pigment was phased out of use and by the 1920s was already listed by common day manufacturers as discontinued. There are several theories regarding the phasing out of the pigment, the two most prominent are that (1) under the Bengal Acts of the 1860s regarding cruelty to animals, the manufacturing process of Indian Yellow was deemed inhumane and cruel to cows and outlawed by the British Raj or (2) the acts of harming a sacred animal in the Hindu culture was seen as poor governance on the part of the British Raj. Either way, the practice was discouraged and gradually ended. There is no legislative evidence of a formal ban. No matter what the reason, there seems to be a sudden stop to traditional manufacture in the early 1900s.

How was traditional Indian Yellow made? This remains a debate within the field; however, recent findings indicate that the production method described by T.N. Mukharji in 1883 is correct—the main component of Indian Yellow is from the dried urine of cows on an exclusive diet of mango leaves and water. Presumably, the urine of any large animal fed a xanthone compound rich diet could produce a similar substance.

The earliest discussions concerning Indian Yellow date from the turn of the 18th century. The earliest written reference the authors were able to find was in Robert Dewhurst's private journal (1787), where he writes a friend regarding its composition and properties. Here we find reference of it potentially being "inspesated [dehydrated] urine" (Dewhurst 1784–1787). Throughout the 18th century, written evidence states that Indian Yellow derived from the urine of several animals including—camels, buffalo, cows, and elephants—that it was developed from a plant source, or it was inorganic in nature. In 1883, Sir Joseph Hooker of Royal Kew Gardens initiated a formal inquiry with the Indian Government about the origin of Indian Yellow after a request from Professor Graebe (a well-known chemist) for a sample of the pigment to do a full chemical examination. The task of discovering the origins of Indian Yellow was assigned to T.N. Mukharji, an employee of the Government of India, who was familiar with Indian artists' materials. As stated earlier,

he provided a full eye-witness account of the production of Indian Yellow where the urine of cows fed almost exclusively mango leaves and water was collected and processed into ball of "piuri" and sent to local markets in Calcutta.

Samples from T.N. Mukharji's travels were sent to Royal Kew Gardens and delegated to Professor Graebe who performed his analyses (Royal Botanic Gardens 1890). He described the chemical components of the raw piuri sample and how the pigment requires processing before being made into a usable pigment for artists paint. The main component—euxanthic acid—was previously isolated and named by Erdmann and Stenhouse in the 1840's (Erdmann 1844; Stenhouse 1844; Erdmann and Stenhouse 1845), though they were unable to determine its chemical structure, was also described by Graebe. The most informative "clue" regarding the manufacture of Indian Yellow in his report was his reference to studies about the physiological production processes to obtain euxanthic acid performed by other scientists in the 1880s. This is one of the last major references in the art-related literature that references the physiological production of euxanthic acid. The initial studies on Indian Yellow pigment by Erdmann and Stenhouse , followed by several others in the 1870-80s are, however, often cited in the biochemical literature regarding glucuronidation—the process (coined in the 1950s) as the initial reference into this biological process (Conti and Bickel 1977). This further supports T.N. Mukharji's accounts in 1883 and what others had reported throughout the 18th century.

The discovery of Indian Yellow oil paints in paint box from Henri Toulouse-Lautrec's estate proved to be a quick start and foundation in this research into the history of the pigment. It has also refueled work on the modern chemical analysis of the pigment, and attempts to synthesize it in a laboratory environment. These studies are currently ongoing. To date, we have had some success in the synthesis of chemically similar molecules, which have comparable optical properties to the authentic pigment.

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STUDIO TIP: ProScope Micro Mobile: High-Powered Handheld Microscope

The ProScope Micro Mobile, a handheld, high-powered microscope, attaches to a smartphone and allows the phone's camera to capture photomicrographs. The digital zoom magnification range is 20x to 80x and has precision glass optics for sharp image detail and accurate color reproduction. The attachment uses LED lights and allows you to increase/decrease the intensity, and they are adjustable in order to reduce surface reflection. It has a USB charging cable and a working time of 2 hours. This product is particularly useful when examining paintings in situ or on research visits. If appropriate, felt can be applied to the front of the attachment case so it can be rested on the artwork.

SOURCE

https://www.bodelin.com/proscope/proscope-micro-mobile
Small microscope with attachment case for mobile phone/iPad; no external/3rd party app required (uses camera app)

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Figure 1. Example of detail image taken with iPhone using ProScope Micro Mobile.

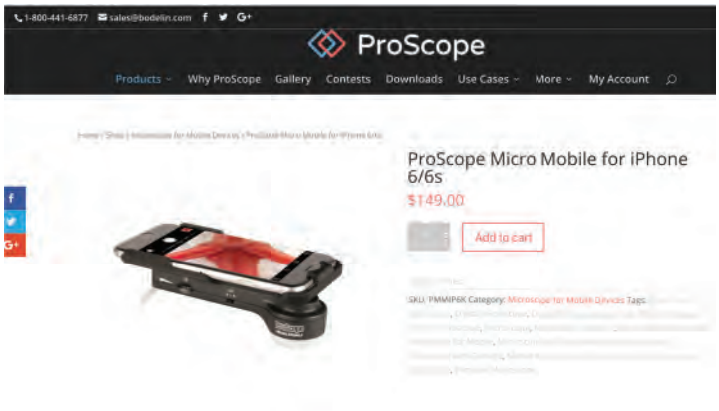

Figure 2. The website for ProScope Micro Mobile: https://proscope-digital.com/shop/digital-microscope-kit-iphone-6-6s/

ALEXA BELLER

STUDIO TIP: Local Humidification Chambers

The local humidification chamber is made using a moistened blotter that is placed within the lid of a pigment capsule (such as that used for a palette of dry pigments) and positioned over the area of the painting requiring humidification (fig. 1). Screw-on caps with clear tops from with cut-to-size moistened blotter inside are also useful to create a local humidification chamber.

The pigment capsules used for this tip are no longer available, but alternative caps can be found as empty lip balm pots sourced on Amazon.

SOURCES:

https://www.amazon.com/New-Clear-Pot-Jars-Containers/dp/B01EGPFBLW/ref=sr_1_cc_4_a_it?s=aps&ie=UTF8&qid=1519413499&sr=1-4-catcorr&keywords=clear+lid+pigment+jar

https://www.amazon.com/New-Clear-Pot-Jars-Containers/dp/B01EGPFBLW/ref=sr_1_cc_4_a_it?s=aps&ie=UTF8&qid=1519413499&sr=1-4-catcorr&keywords=clear+lid+pigment+jar

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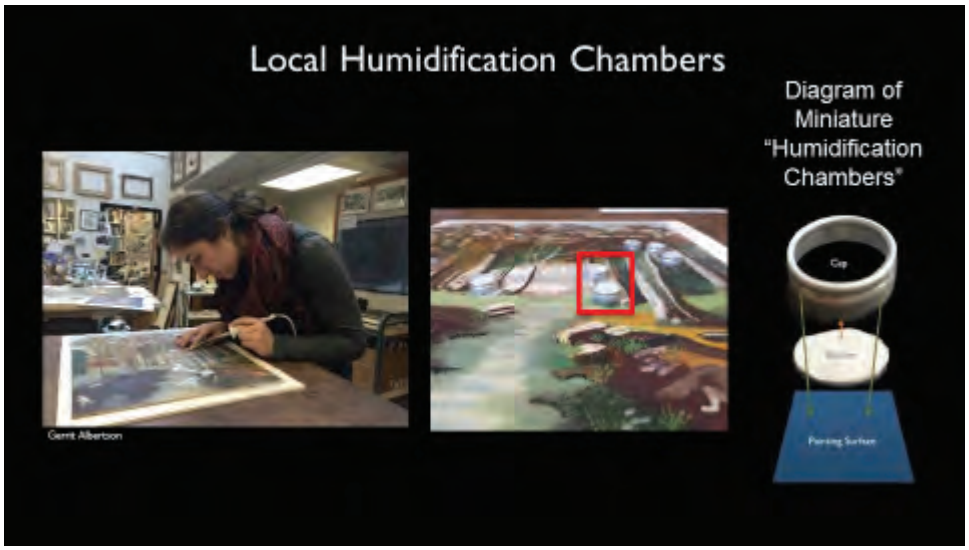

Figure 1. Small cap lids fitted with moistened blotter were used as local humidification chambers to relax isolated areas of lifting paint prior to securing with a heated spatula.

JOSH SUMMER

STUDIO TIP: Inexpensive, Battery-Powered Mixer for Preparing Emulsions, Gels, and More!

The Norpro mixer is inexpensive, while sturdy and long-lasting. It is a great addition to any studio large and small. Using the two-pronged tip helps to create very stable emulsions with extremely small phases, generating a larger surface area for each phase, thus speeding up dissolution and uptake of coatings or overpaint without the need to add more solvent or other active ingredient. The mixer comes with other tips as well which can be used to mix adhesives and other materials.

SOURCE:

http://www.amazon.com/Norpro-Cordless-Mini-Mixer-Piece/dp/B000E39LYO

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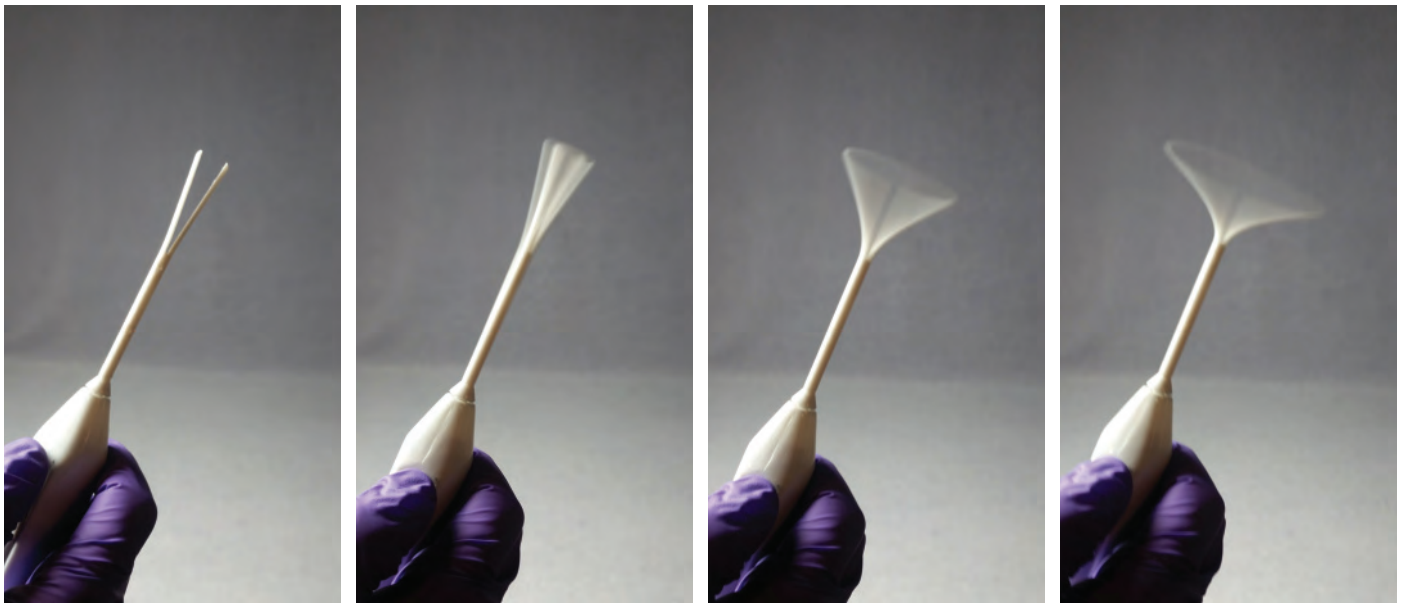

Figure 1a–1d. With the press of a button on the handle, the Norpro mixer's two-pronged tip opens wide while spinning. It is powered by two AA batteries.

STUDIO TIP: X-Raying Cradled Panel Paintings

A number of materials potentially suitable for filling panel-painting cradles prior to x-ray radiography were researched and tested at the Indianapolis Museum of Art (fig. 1). These fillers include Elvacite 2045, Elavacite 2044, Elvacite 2046, poly(vinyl alcohol), Butvar B-76, Paraloid B-72, and wood flour. Of this list, Elvacite 2045 [poly(isobutyl methacrylate)] was determined to be the best material for this task. The other materials tested were prone to clumping, too visible in the x-ray radiograph, or ineffective at reproducing the density of the cradle members.

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Figure 1. Results of cradle filling tests

STUDIO TIP: "Milkshake" Paintable Fills

A recipe for a paintable fill material, originally formulated by Yasuko Ogino and James Squires, is described for a "milkshake" paintable fill (1 part Modostuc or spackle: 1 part acrylic gesso with dry pigment and water added to a consistency of a melted milkshake). It is so-named because it is mixed to the consistency of a milkshake. This fill material can be brush-applied within areas of loss and is particularly useful in retaining some canvas texture. The fill can be formulated with colored spackle, colored gesso, and various dry pigments to achieve a range of colors. The fill conforms to canvas texture best when applied in thin layers, but a thicker mixture will hold the brush texture from the fill application.

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Figure 1. Detail, partial raking light. Paul Louis Narcisse Grolleron, *Soldier Carrying a Wounded Soldier*, Art Institute of Chicago, RoF 037326, 18 1/8 x 12 3/16 inches, during treatment

Figure 2. Detail after filling with "milkshake fill," raking light. Paul Louis Narcisse Grolleron, *Soldier Carrying a Wounded Soldier*, Art Institute of Chicago, RoF 037326, 18 1/8 x 12 3/16 inches, during treatment

STUDIO TIP: The Flat-Lay Pack Method

For work on-site, I have taken a tip from travel magazines blogs on packing recommendations. I find it particularly useful to lay out all of my tools, materials, and equipment in a "flat lay" for inventory check against a running digital checklist. Digital copies of the checklist and equipment flat-lay are saved with each project file for future reference.

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Figure 1. Figure of a travel blog "flat lay" for packing.

Figure 2. Figure of small hand tools, dry goods and materials, and equipment for an on-site trip to Alaska in carry-on or checked luggage. All chemicals are clearly labeled and Safety Data Sheets are included in the luggage.

CHECKLIST

	Material
☐	optivisors
☐	laptop, charger, cable, usb-c/b converter
☐	camera, charger, usb cable, polarizer, uv filter
☐	color checker
☐	nitrile gloves, medium (4)
☐	measuring tape (soft, 6')
☐	measuring tape (retractable, 12')
☐	flashlight
☐	uv flashlight
☐	goat hair dusting brushes
☐	microfiber dust cloths
☐	handheld microscope
☐	notebook and pens/pencils
☐	roll blue tape
☐	japanese tissue paper, wet strength
☐	japanese tissue paper, thin
☐	hollytex
☐	scrap ecru cotton
☐	blotter
☐	satin/silk
☐	screwdriver
☐	wirecutters
☐	awl
☐	brass mending plates
☐	screws, #6
☐	finishing washers, #6
☐	D-rings, mini, 6
☐	D-rings, 2", 12
☐	D-rings, 3", 12
☐	volara foam, self-adhesive, 1 full+
☐	Cotton wool, long-fiber, 1#
☐	skewers (4)
☐	dental picks
☐	clay shapers
☐	tweezers
☐	caselli spatulas
☐	scalpel
☐	#15 blades (3)
☐	Beaver blade
☐	6700 blades (3)
☐	whetstone or diamond plate
☐	Modostuc
☐	Golden molding paste (hard and regular)
☐	gesso
☐	animal glue granules
☐	fish glue (cast dried flakes)

Figure 3. Digital checklist sample. This is updated as each project evolves to inform future projects.

Figure 4. (*left*) Small amounts of water-based liquids can be decanted into disposable 1-ounce containers and carried into clean spaces or galleries, and disposed or recycled at the end of the project. These can usually be found in local discount or restaurant supply stores. (*right*) Men's shaving brushes are made of badger hair, they may be more easily obtained and more cost effective. These are also easier to pack for site-work. Quality varies widely.

JUDY DION

STUDIO TIPS: Adaptive Uses for Washer Head Screws, Muffin Fan, LED Clip Light, and T-track Kits

A number of product recommendations were presented, including the following:

I. WASHER HEAD SCREWS

Washer head screws can be used for attaching backing boards as a replacement for finish washers and wood screws.

SOURCE:

Teks Lath Screws (pointy tip): Home Depot and/or Lowes or other hardware stores

Figure 1. Washer head screw used for backing board attachment

II. MUFFIN FAN

A computer cooling fan (or "muffin fan") can be used for low solvent extraction from studio spaces. The fan can be attached to a range of surfaces or perched in a window or on a table, and it is the same diameter as flexible vinyl duct for making a low-cost fume extraction set-up for low-solvent loads.

SOURCE:

Muffin fan: http://www.amazon.com/AC-Infinity-HS9238A-X- Standard-Cooling/dp/B009OXMZ3Y

Figure 2. Muffin Fan (Courtesy of AC Infinity/Amazon)

III. CLIP-ON LED SPOTLIGHTS

Small clip-on LED spotlights with flexible necks can be attached to a microscope boom. These are low-cost alternatives to fiber optics and produce just as much light.

SOURCE:

JANSJO clip light from IKEA

Figure 3. Clip-on LED spotlight attached to microscope boom

IV. T-TRACK FOR CLAMPING

T-track can be used for temporary or permanent clamping needs, easel construction, or a height-adjustable armrest for working on large paintings on-site.

SOURCE:

T-track kits: http://www.rockler.com/universal-t- track-universal- t-track

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Figure 4. T-track used for a temporary easel

STUDIO TIPS: Adaptive Uses for Vacuum Attachments, Glass Medicine Droppers, and Picture Framers' Brad Setters

I. VACUUM ATTACHMENTS

Vacuum attachments made for cleaning computer keyboards can be modified by filing or sanded down to reach behind stretcher bars. Mat board or G-10 can be cut in shapes with hooks on the end and then taped to these attachments as well to grab and gently dislodge dust bunnies, nails, old keys, or other trapped debris.

SOURCE:

http://www.amazon.com/Micro-Vacuum-Attachment-Kit-Piece/dp/B000BSJCLY/

II. GLASS MEDICINE DROPPERS

Glass medicine droppers can be used for putting Tinuvin in varnish (make sure they are glass!). 1 mL of Tinuvin 292 weighs approximately 1 gram.

SOURCES:

http://www.amazon.com/Bodico-2-pc-Glass-Medicine-Dropper/dp/B00N5WQ2LQ/

https://www.amazon.com/Glass-Graduated-Pipette-Dropper-Rubber/dp/B01LLEMEUW/ref=pd_sim_121_6?_encoding=UTF8&pd_rd_i=B01LLEMEUW&pd_rd_r=AAGVBG53E5R4XKQFSXVJ&pd_rd_w=2w2JG&pd_rd_wg=1j3QV&psc=1&refRID=AAGVBG53E5R4XKQFSXVJ

III. PICTURE FRAMERS' BRAD SETTERS

Picture framers' brad setters can be used to push tacks into stretchers instead of hammering to reduce shock. Pre-making the hole with a push pin will keep the tacks from bending and will help to make sure that the tacks go in easily. A piece of mat board should be put in between the stretcher and canvas to guard against unintentionally poking the back of the canvas with the brad setter.

SOURCE:

https://www.woodcraft.com/products/picture-framing-brad-setter?gclid=CjwKCAjwypjVBRANEiwAJAxlIhqkN5i-2lC5xFRPalMg0CmMGBLlwYqAPfZoOLJo6QZx5g-foamaO2BoCbcgQAvD_BwE

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STUDIO TIP: Mobile Painting Storage

When ArtCare Conservation's Miami Studio moved to a new location, it was an opportunity to expand and upgrade the storage rack where paintings were kept while they were being treated. Because the studio was in the subtropics where hurricanes can cause leaks and flooding, the structure needed to be movable, water resistant, and allow good air circulation. Darren Price, a preparator for a local museum, carried out our design for a unit measuring 8 ft. high, 155 in. long, 42 in. on one end, and 102 in. on the other end (fig. 1). The unit and base were framed out with 2 x 4 studs. The top and bottom were covered with marine grade plywood. The structure was placed on large swivel dolly wheels. These eight-inch, hard rubber wheels would enable us to move the rack away from any water intrusion. With the wheels and the base, the paintings would be 12 in. above floor level. Jacks were purchased to give additional height in the case of severe flooding.

Rows of PVC pipes, placed four to 6 in. apart were attached to frames of 1 x 2 strips. These were fitted to the interior to create racks within the plywood frame. One section of the racks was divided horizontally to allow for smaller storage spaces. The base where the paintings rest was covered with clear vinyl flooring, for ease of moving the works and to separate them from the wood.

A waterproof boat cover was commissioned to cover the entire unit (fig. 2). At one end, the fabric was extended so when the cover was zipped, there would be a space to house a dehumidifier, if needed, to stabilize the climate within the unit.

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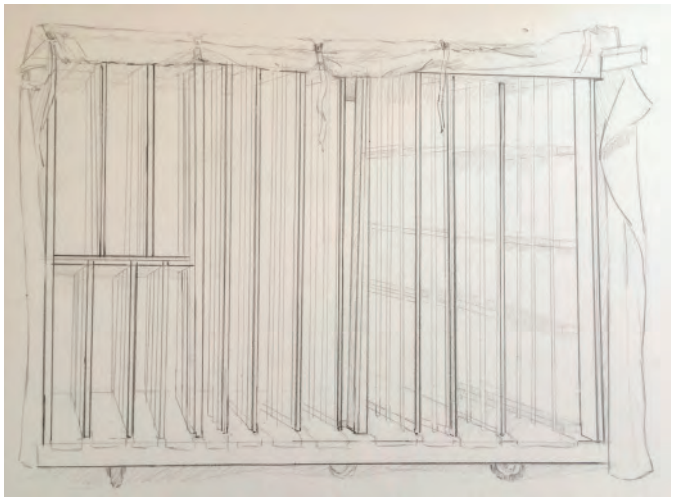

Figure 1. Drawing of mobile painting storage unit

Figure 2. Boat cover over storage unit

CAROLYN TOMKIEWICZ

STUDIO TIP: Pocket-Sized Projector

A wireless/iOS and Android capable pocket-sized projector was presented. It is useful for impromptu or in situ presentations. There are several products on the market, the one presented was a Miroir HD Projector.

SOURCE:

http://www.amazon.com/gp/product/B0187U947E

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STUDIO TIP: Muji Black Cotton Swabs

Muji black cotton swabs have been found to be useful for cleaning tests on light-colored paintings and objects. The black cotton swabs can also be useful for testing sensitivity of light-colored paint passages.

SOURCE:

http://www.amazon.com/gp/product/B00GHDK32Y

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SHORT PRESENTATION: Update on the Information on the Reverse of Paintings Database

The Information on the Reverse of Paintings (IROP) database is a resource devoted to the documentation, compilation, and organization of canvas stamps, stencils, inscriptions, labels, and wax seals commonly found on the reverse of paintings. The database, which is housed by the Fine Arts Museums of San Francisco website, makes this material available in searchable form. Contributors to the database register to upload information, and users are expected to also be contributors. In the interest of security and permissions, a login is required.

The site is currently in beta-testing and feedback from testers is requested. Some of the upcoming work will include defining terms and conditions for users and looking into the possibility of developing different levels of visibility for different users.

Please contact the author if you are interested in participating in beta-testing of the website.

WEBSITE: https://irop.famsf.org/

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