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2015-2018

american institute for conservation
Preserving Cultural Heritage

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2015 – Research and Technical Studies Specialty Group Presentations

Back to Natural Processes: Controlled Carbonation for Recalcifying Malacological Artifacts

Edgar Casanova-González, Jocelyn Alcantara Garcia, Nora Perez

Mesoamerican archaeological burials and offerings often contain numerous artifacts made of seashells, with a number ranging from one or two to hundreds. Marine mollusks' shells structure is formed by different crystalline arrangements of calcium carbonate. Seashells were used in Pre-Hispanic Mexico as musical instruments, jewelry, decoration for textiles and money to name just a few examples. Therefore, they contain valuable historical information about the traditions and technology of these cultures. Since the seashell artifacts were buried for hundreds of years they suffered severe degradation processes. Main degradation mechanism consists in solubilization of the large amounts of proteins that lie between the crystals of calcium carbonates in humid environments. As a consequence, archaeological malacological objects are frequently highly unstable and prone to delaminate. Their extraction, storage and consolidation are challenging due both to their number and severe degradation. Although some methodologies have been tested for their stabilization, such as the use of caseinate, lactose, quitin and acrylic polymers, none of them has been, to date, entirely reliable in the long term. The novel methodology we propose consists in slowly growing calcium carbonate crystals within the pores of the artifact. The method was firstly tested on artificially degraded artifacts, followed by tests on archaeological material donated for this research. Our method starts with a humidity stabilization stage, followed by water substitution by a calcium hydroxide solution. The last stage consists of a controlled calcification period in a chamber engineered to have a controlled carbon dioxide atmosphere. Ultimately, we are not only stabilizing the tested malacological material with a highly compatible compound but also consolidating it in the long term.

BronzeShield™: A Durable and Selectively-Removable Clear-Coat for the Protection of Outdoors Bronze Statues

Dante Battocchi

Bronze is especially susceptible to deterioration caused by atmospheric corrosion and, delaying corrosion is one of the most important aspects of surface preservation. To do that, barrier coatings are often used. BronzeShield™ was formulated to protect outdoor sculptures with durability and easy removability as key properties. The development of a selectively removable coating for the protection of bronze has been a focus of research at North Dakota State University's Department of Coatings and Polymeric Materials since 1999 and has resulted in the invention of a new polymer. Elinor Specialty Coatings licensed this technology and further developed the polymer to produce BronzeShield™. Through this research, Elinor developed a modified polyester-urethane clear coat that is both protective and selectively removable. A zero-VOC non-toxic remover was also formulated to selectively remove the clear BronzeShield™ without damaging the bronze surface or patina. This combination coating-remover eliminates the need for harmful solvents (e.g. Toluene or Xylenes) or aggressive physical/mechanical means (e.g. sandblasting or wire brushing). BronzeShield™ was recently tested on flat bronze panels both outdoors for 2 years in Fargo, ND and in accelerated weathering for 1000 hours. In addition, it was field-tested on an outdoor monument in collaboration with McKay Lodge Conservation Laboratory, Inc. The accelerated weathering confirmed that BronzeShield™ outperforms its commercial benchmark and maintains a better exterior appearance. The outdoors exposure confirmed the coating durability and BronzeShield™ maintained its full removability after each of the exposure studied. The field test on the outdoor statue showed that the coating saturates the weathered surface in a manner similar to wax, it is easy to apply, it is fully removable and conforms to the current conservator's practices.

Identifying Past Restoration Processes through Instrumental Analysis

John Twilley

Documentation of the past treatment that an artwork has received is very often absent or lacking in significant technical details. The reasons for this include undocumented traditional procedures that are culturally-determined but not widely known outside of the culture; loss, decay, or obsolecence of records; the effects of that most irreversible of all steps - cleaning; and cursory or biased accounts created under the pressures of the art market. The ambiguity that frequently surrounds past treatment creates an opportunity for the unscrupulous to exploit by embellishing or falsifying aspects of an artwork. It is not unusual to encounter modern embellishments of ancient works that have been "laundered" (made substantially harder to recognize) by subsequent restoration treatments carried out by a conservator who, when given the too-narrow mandate to treat some new problem of the object without the resources to fully investigate its prior treatment, inadvertently restores these embellishments, unifying their appearance with that of the object. The conservator steps into this information gap facing the prospect of time-consuming and often costly treatment efforts which have the potential to erase historically significant attributes acquired by the artwork over time or to consume conservation resources in the pursuit of unclear treatment objectives. Microchemical and microstructural analyses by the conservation scientist can serve to reconstruct parts of this missing history, thereby informing treatment decisions at an early stage, and often providing important art historical information in the process.

Case studies from a broad spectrum of materials will serve as examples of this aspect of conservation science including:

-The historical treatment of ancient Chinese bronzes in Japanese collections;

-The discrimination of ancient foundry repairs in a Chinese ritual bronze from modern restorations carried out by traditional Japanese methods;

-Embellishment by the addition of modern decoration to ancient but originally undecorated Chinese bronzes;

-An unusually brilliant surface of a Buddhist ritual bronze suspected of modern regilded; -Salt crystalization damage to French earthenware ceramics caused by chemical transformation of residual cleaning agents;

-An unusually localized case of embrittlement in a latex costume that has been shown to involve prior restoration;

-Pitfalls in the use of portable X-ray fluorescence as a means of locating residues of mid 20th century retouchings from an early 20th century painting.

Micro Extraction for the Spectroscopic Identification of Binding Media in Early 20th Century Matte Paint

Lauren Klein, Chris McGlinchey, Ellen Moody

As part of an ongoing investigation into the materiality of early 20th century matte commercial paint, this research hopes to increase the signal intensity for the binder, starting with oil, when employing FTIR by using a micro extraction technique on a highly reflective surface. Our investigation is meant to be as inclusive of paint media as possible: consequently our interests include traditional matte artist's paint in addition to commercial paints ranging from DIY 'housepaint' to graphic design paint. The technique was developed by using paint samples from early 20th century house paint brochures and then subsequently applied to the technical studies of matte paint in non-painting works (e.g. drawings, prints, and architectural models) in MoMA's collection. Non-painting works, rather than paintings, were chosen for the first part of this study in the likelihood that they would not only most likely contain unmixed and unadulterated paints but also that they would be relatively free of conservation adhesives, consolidants, or varnishes and, thus, could allow more confidence in the identification of the paint's original components and increase understanding of its use in art work. The samples of matte paint were first screened using FTIR in transmittance and samples that showed signs of an oil binder, e.g. weak carbonyl, were used for further analysis using FTIR in reflectance. These samples were placed on a reflective aluminum metal support with a textured surface to help concentrate the extracted materials. The samples were hydrolyzed by treatment with an alkali and then saturated with an organic solvent. The separation and presence of the oil binder was confirmed by collecting FTIR data, informed by UV examination, in reflectance mode on the deposited residue that collected on the metallic surface just outside the particulate matter of the sample. This research confirms that a micro extraction technique is useful for matte paint with an oil binder because not only do these paints typically have a lower amount of binder than glossy enamel paints, which makes the binder signal weak, but also their significant oil identification peaks can be obscured in an FTIR spectrum by inorganic peaks, like barite and calcite which are common fillers in matte paint. The two-step hydrolysis-extraction procedure was successful at separating the oil from the pigment/filler matrix leading to improved detection of the oil with strong signal and well resolved baseline. Currently, this process has been successful with paint particles as small as 10 mg and further research is being done to optimize the procedure and determine its limits of detection. Since the particle size required is on the low end of detection for GC-MS, this technique may provide an alternative, albeit more general, method for binder investigation when particles prove too small for GC-MS. This research hopes to provide a quick, easy, and confident test for the presence of oil, and eventually other binders, in paints where the FTIR spectroscopy signal for the medium is ambiguous. Additionally, the technique is directly applicable to the study of matte paints on non-painting works, where the confirmation of binder type can help to inform on the type of paint used.

New Inorganic Consolidants for the Restoration Market: Results from Nanomatch EU Project

Adriana Bernardi, Francesca Becherini, Arianna Vivarelli, Alessandra Bonazza, Alexandra Geiss, Barbara Lubelli, Bastiaan Verhey, Bernhard Moeller, Elsa Bourguignon, Gabrielle Poulet, Gerhard Schottner, Ingemar Svensson, Irene Natali, Iulian Daniel Olteanu, Luc Pockelé, Marco Pancani, Maria Dolores Romero Sanchez, Martin Labouré, Matteo Chiurato, Monica Favaro, Oihana Garcia Mercero, Patrizia Tomasin, Rob VanHees, Sandro DeGrandi, Timo Nijland, Ulrike Brinkmann, Vicente Javier Forrat Perez, Vincent Detalle

The problem of deterioration of heritage materials has become increasingly urgent due to: i) the increase of natural weathering caused by climate change and atmospheric pollution; ii) the current use of inappropriate commercial products and their fast deterioration; iii) the need of a more sustainable management of the built heritage. Therefore, there is the demand to improve the actual products and conservation methodologies or to develop new valid alternatives. The NANOMATCH project ("Nano-systems for the conservation of immoveable and moveable polymaterial Cultural Heritage in a changing environment", Grant Agreement no. 283182 of European funding FP7) addressed these issues combining the most recent advances in the fields of nanotechnologies and conservation science.

The starting idea was that alkaline earth and semimetal alkoxides are suitable molecular precursors of consolidants since they create a nano-structured coating adherent to pore walls (stone, stone-like and wood) or to the internal cracks (glass). Particularly calcium alkoxide can be considered as strengthener for stone and as alkaline supply for wood. Concerning glass materials, a molecularly dispersed aluminum alkoxide complex penetrates in the smallest capillaries of corroded glass thanks to its very low viscosity and it behaves as glass-in-glass consolidant.

Workability, efficacy, compatibility and durability were assessed in comparison with commercial products both in laboratory and through exposure of treated model samples (sound and artificially weathered) and degraded historical surfaces in four sites: Cologne Cathedral (Germany), Santa Croce Basilica in Florence (Italy), Oviedo Cathedral (Spain), Stavropoleos Monastery in Bucharest (Romania).

Results showed good penetration and microcrystalline crystallization of the consolidant within porous stones without significant aesthetic effects. Thanks to the fast alkoxide reaction time, a good surface cohesive effect was rapidly achieved and after exposure it further increased in the deeper layers. In stone-like materials the treatment performances were quite similar but strictly related to the type of binder and pigment. In wood samples, an effect of preservation against fungal attack and pH acidification was attained in combination with a biocide. The product developed for the glass ensured high transparency even after long-term exposure outdoors and stability under medium relative humidity conditions indoors.

Finally, risk assessment of nanoparticles exposure was performed. Measurements successfully demonstrated that any nano-particles release took place neither in their manipulation nor after treatment.

These new advanced products offer a variety of possible applications starting from the same class of compounds then tailored in relation to the specific conservation needs. Hence, they mark a new generation of restoring inorganic products, compatible with the original materials, easy applicable to indoor and outdoor Cultural Heritage and low cost.

Parylene Treatment for Paper/Book Strengthening

Lei Pei, John Baty, Mark Pollei, Sonja Jordan Mowery

Parylene (a class of polymers with the base monomer para-xylylene), deposited via chemical vapor deposition (CVD), has been used as a practical treatment to strengthen cultural heritage papers. The deposited monomers polymerize in situ, forming a thin, conformal coating that strengthens paper. Other unique properties of this technology are its mold resistance and its ability to treat multiple pages at once. In the 1990s, Parylene treatment for cultural heritage paper strengthening was studied by several investigators including Don Etherington, David Grattan, and Bruce Humphrey, who demonstrated a significant increase in the strength of treated versus untreated papers. In the last 20 years, however, this treatment has received limited recognition within the conservation community and no further study. Stated concerns include the uncertainty about the permanence and durability of the imparted properties and the lack of reversibility. There are now several reasons, however, to revisit Parylene as a conservation treatment for cultural heritage papers. First, certain important assessments of the efficacy of Parylene treatment were not performed in the previous work. These include the optimization of the Parylene layer thickness for conservation needs, the aging of treated papers rather than the films by themselves, and the ability to conduct subsequent conservation treatments following deposition. Second, recent technological developments may now make Parylene more useful to conservation: There are now (1) CVD deposition chambers that are cheaper and more compact, (2) new analytical techniques to characterize the coating, and (3) new Parylene materials, including soluble Parylene, which addresses the concern over reversibility. Beginning summer 2012, Heritage Science for Conservation at Johns Hopkins University convened two roundtables of scientists, conservators, and industry representatives to discuss paper strengthening and Parylene technology. We reviewed both published and unpublished reports, examined numerous artifacts treated in the 1990s at CCI and Etherington Conservation, and interviewed the scientists who performed the research. After duplicating previous strengthening results, we optimized the Parylene layer thickness to maximize the strengthening effect while minimizing side effects such as stiffening using conservators' feedback. We will present the results of mechanical testing and the behavior of Parylene coated paper in conventional paper conservation treatments to show the degree to which Parylene coating improves the durability of brittle papers on its own, or in conjunction with other conservation treatment. Our results show that groundwood pulp book papers from 1951 with a ~ 400nm Parylene coating retain many of the characteristics of new wood pulp papers in terms of rattle, turn radius, and general tactile experience. The treated paper has a > 30% improvement in tear resistance and more than three times higher folding endurance. Additionally, Parylene treated paper is receptive to, and can even improve upon, conventional paper and book conservation treatments such as tear mending, guarding, washing and resizing, and book and case binding. An acknowledged limitation of Parylene treatment is that there appears to be little improvement on the folding endurance of very brittle, low porosity papers. In conclusion, Parylene treatment imparts mechanical strength, especially tear resistance, to uncoated papers, but is especially promising for groundwood pulp papers, where it also imparts folding endurance.

Piet Mondrian – Broadway Boogie Woogie

Cynthia M. Alberston, Ana Martins, Anny Aviram, Joris Dik

With twenty five drawings, watercolors, and paintings, the Museum of Modern Art holds the largest and most comprehensive collection of works by Dutch abstractionist Piet Mondrian in North America. Spanning from 1902 to 1943, sixteen of these works are oil paintings and include his last completed masterpiece Broadway Boogie Woogie. Mondrian painted Broadway Boogie Woogie in his mid-town studio at 15 East 59th Street in New York City between 1942 and 1943. MoMA acquired the painting in 1943. Early on conservators noted a number of condition issues and since its time in the museum's collection has warranted several treatments to date - Mostly to address ongoing cracking and the oozing of red paint through cracks in overlying yellow paint. The support, preparation layer, composition of the paints, how they were applied, and previous treatments all play a role in the paintings condition. Over the last five years conservators and scientists have closely collaborated utilizing the latest technology to study the Mondrian collection through examination, documentation, technical analysis, re-treatment, and inter-museum collaboration. Technical examination has included imaging, X-radiography, and Reflectance Transformation Imaging (RTI). Most recently macro X-ray fluorescence spectroscopy (MA-XRF) combined with Multivariate Image Analysis (MIA) was used to simultaneously identify and map the different pigments and paints used in Broadway Boogie Woogie. The spectral information collected over the whole painting revealed the presence of key elements representative of pigments, fillers, and in some cases their source or manufacturing process. MIA was used to further elucidate the composition of the paints by examining the correlation between the different elements present. Mapping the elements based on the MA-XRF analysis as well as mapping the pigments and paint components based on the MIA analysis on the other hand helped visualize the artist process including the extensive reworking and repainting of the surface. This cumulative research will elucidate the complexity of Mondrian's studio practice during a time when he was making the most monumental and masterful paintings of his career.

Pollutions Induced (?) Crystal Formation on Edvard Munch's Aula Sketches

Erika Gohde Sandbakken, Alyssa Hull

White surface crystals have been observed in 15 sketches from Edvard Munch's Aula sketches (1909-1910). These were visible in both exposed areas of the unprimed cotton canvases, on crayons and on strokes of paint. White crystals found on oil paintings are often identified as fatty acids and metal soaps. However, zinc-, magnesium- and zinc magnesium-containing sulfates were identified (XRD, SEM EDS/EDX) in several samples. Magnesium sulfate is an efflorescent salt more commonly found on the surface of porous buildings and mural paintings. The aforementioned salts have also been identified on other paintings on canvas and on paper.

Previous analyses have been used to explain and understand the formation and reactions of these metal salts. No clear correlation was proved between the oil media, animal glue, wax and oil crayons and possible layers of casein that have been identified with FTIR, GK-MS and DTMS. Semi-qualitative XRF measurements indicated high amounts of sulfur (S), potassium (K), calcium (Ca) and zinc (Zn) in areas with bare canvas and on crayons and paint layers. This may indicate that the sketches were exposed to pollution and/or that the canvases were pre-prepared with a substance that is not visible to the naked eye. Particles of pollution appear to readily adhere to porous and irregular surfaces and the general porous character of the surfaces have made it easier for the metal salts to crystallize and effloresce on to the surface. The crystals are chemically active, and will rehydrate or dehydrate under various relative humidity and temperature parameters (magnesium sulfate heptahydrate will rehydrate in room temperature at 41-51% RH). A rehydration of the salt could, in turn, cause damage as the volume of the crystals grows. The identified salts found on Munch's sketches were indicated by XRD to be in three different hydration states, which make it challenging to provide specific recommendation regarding storage conditions.

Munch's treatment and use of his materials – such as his decision to paint the Aula sketches on unprimed cotton canvases that were potentially pre-treated with alum – as well as the storage history of these works both during and after Munch's lifetime will be considered to explain the current conditions of the sketches and the unique vulnerability that may have been posed to them by environmental pollutants. Three types of new cotton canvases were aged for a period of three months. One of the new textiles had been pre-prepared with an alum-wash. These aging tests gave a good indication on the degradation progress of the pre-preparation. Based on the tests new hypothesis were made on how a possible pre-preparation could have made the sketches more susceptible to pollution adherence to the porous surfaces.

Polymer Coating Removal Nanosystems for Finely Controlled Cleaning of Cultural Heritage

Piero Baglioni

Works of art and artifacts that constitute our cultural heritage are subject to deterioration. Their surfaces interacting with the environment are the most prone to aging and decay; accordingly, soiling is a prime factor in the degradation of surfaces, chemical and mechanical degradation are often associated to soiling and lead to the disfigurement of a piece of art. The effects of these processes are usually strongly amplified in the presence of protective coatings (mainly acrylic and vinyl polymers), applied in previous restoration treatments. In the past years we pioneered the synthesis and the application of several advanced systems for the consolidation and the cleaning of works of art, as hydroxides nanoparticles, microemulsions and chemical/physical gels. In this talk examples from self assembled systems for the cleaning or the removal of coatings from pictorial surfaces will be highlighted. Micellar solutions and microemulsions constitute very efficient systems for the removal of acrylic, vinyl and alkyd polymers or grime/dust. These systems (as well as neat solvents used in "traditional" conservation) can be confined into chemical and physical gels having proper nano-domains for the upload or the delivery of compounds from/to the work of art. For example, a fine control of the cleaning procedure can be obtained even for challenging cleanings as water sensitive works of art, where the cleaning can be achieved by using water confined into gels, and leaving no residues on the works of art.

The Deacidification of Contemporary Drawings: A Safe Method Based on Nanotechnology

Giovanna Poggi, Antonio Mirabile, Piero Baglioni, Giorgi Rodorico

The conservation of cellulose-based works of art is threatened by the presence of acidity inside the substrates, developed upon ageing or native, i.e., due to the papermaking process. The depolymerization of cellulose due to acidic compounds eventually leads to the complete loss of mechanical properties of the artworks. Many strategies for hampering the acid-catalyzed degradation of cellulosic substrates have been developed, many of them based on mild alkaline compounds dispersed in polar or low polar solvents. Unfortunately, few are the available treatments that can be safely used on contemporary drawings or contemporary art on paper. As a matter of fact, during the 20th century, the notion of drawing underwent great change. The use of paper started to change in the middle of 20th century changing from a simple support for studies or sketches to form the basis for an autonomous work, at time torn, burnt, folded, perforated, twisted or scraped. At the same time the world of art has seen the arrival of a large number of new media, such as acrylic and vinyl resins, pressure sensitive adhesives, ballpoint and felt-tip pens and markers. All of these media are rarely compatible with traditional restorative procedures. This makes the conservation and restoration of the wide field of contemporary drawings unexplored. In the present communication, a method for the pH-control of cellulose-based works of art, completely compatible with ballpoint and felt-tips pens drawings, but also respecting the folded or creased topography of the paper, will be presented. A multidisciplinary team, composed by material and colloids scientists and paper conservators, has conducted this research, with the aim of tailoring an innovative deacidification methodology for an unresolved conservative issue. In recent years, alkaline earth metal hydroxide nanoparticles dispersions have demonstrated to be efficient for the preservation of cellulose-based artifacts, providing a stable neutral environment and, if in excess, turning into mild alkaline species. New formulations have been recently obtained via a solvothermal reaction, starting from bulk metal and short chain alcohols. The most interesting feature of these nanoparticles is their dispersibility in cyclohexane. Cyclohexane is a colorless, volatile, nonpolar liquid. Due to its high volatility, the spraying of the solvent guarantees a fast and simple application, respectful of the original artist's technique. Due to its nonpolar character, cellulose fibers are not affected by cyclohexane. Therefore, even in the case of creased or folded paper, such as Simon Schubert, Kiki Smith or Stefano Arienti artworks, the treatment will not cause any changes in the original visual aspect of the object. In order to evaluate the efficacy of calcium hydroxide nanoparticles dispersions in cyclohexane, mockups were prepared on acid paper by using ballpoint pens and felt-tips. The compatibility between the deacidifying formulation and the samples were tested upon ageing, by pH and colorimetric measurements. The promising results obtained on these preliminary tests led to the

application of this innovative formulation on contemporary drawings from a private collection, potentially paving the way for the treatment of such an important field of contemporary arts.

The Technical Study and (Re-)Restoration of a Limoges Painted Enamel Plaque

Gregory Bailey

A late 16th-century Limoges painted enamel plaque at the Metropolitan Museum of Art depicting Diana and Proserpina (32.100.263) has been the subject of recent technical study and curatorial research. Though the plaque is signed "IDC," the artist's identity is unclear, as several members of the Court family signed their works with the same initials. The plaque was known to have painted restorations around the border and an inserted "patch" on Diana's skirt of new enamel laid over the copper substrate. Previous scanning electron microscopy with energy- and wavelength-dispersive x-ray spectroscopy performed by Research Scientist Mark Wypyski identified chromium in the enamel patch, a colorant not used in enamels before the 19th century, thus serving as a terminus post quem for the restorations. The painted restorations to the border reconstructed a gilt motto as the nonsensical phrase "ESTES PARVBIQVITE." Recent art historical research undertaken by curators Elizabeth Cleland and Yassana Croizat-Glazer identified the correct original motto as "POTESTAS PAR VBIQVE"; armed with this information, it was requested that the original motto be restored to the object. Initial examination suggested that the prior restorations were much more extensive than previously realized, and included a large section of the border text. After consulting with curatorial staff, a technical study was undertaken to provide additional information about the materials and techniques employed by the original artist as well as the extent and nature of prior restorations. Visual examination under binocular magnification, x-radiography, reflected ultraviolet photography, long- and short-wave ultraviolet induced visible fluorescence photography, and reflected near infrared photography were conducted along with x-ray fluorescence spectroscopy of enamel surfaces. This study yielded significant information on the structure and condition of the plaque as well as the composition of the enamels and their method of application and revealed previously unrecognized details such as the use of silvering for important details. The sophisticated restorations to the border and lower portion of the plaque were identified as newly made pieces of enamel employing colorants typical of the 19th century. Intriguingly, the method by which these enamels were produced and adhered to the original portion of the plaque does not correspond to the technique of soldered enamel "patches" described in the literature on 19th-century enamel restorations. The possibility is thus raised that the techniques of traditional enamel restorations may be more diverse than currently recognized. To preserve these restorations intact for future study while restoring the original motto, a novel treatment approach was devised. Drawing on the idea of 19th-century enamel "patches" as well as glass filling techniques developed by Gorazd Lemajic and refined by Metropolitan Museum conservators Lisa Pilosi and Karen Stamm, a very thin tinted epoxy mask was separately cast to conform to the surface of the enamel restorations on the border. The mask was adhered around the edges using Paraloid B-72 and the correct text of the motto was then painted onto the surface. This treatment is more readily reversible than painting over the restoration enamel, and could be adapted to fill losses to enamels as well.

2015– Research and Technical Studies and Paintings Specialty Group Presentations

Educating Handheld XRF Users in Cultural Heritage: XRF Bootcamp for Conservators

Lynn Lee, Aniko Bezur, Karen Trentelman

The ability to employ non-invasive and non-destructive analytical methods that can be used in situ is essential in the study of works of art and other cultural heritage materials, as the removal of samples for analysis is generally severely limited, or in many cases forbidden. As such, X-ray fluorescence spectroscopy has arguably become the most widely employed analytical technique in the scientific examination of works of art. While only a few museums could afford the open-architecture units first available in the 1980s, the subsequent proliferation of relatively inexpensive and easy-to-use handheld spectrometers has enabled this technique to be acquired by a much larger number of institutions and operated by a wider range of users. In many of these institutions, the responsibility for operating the instrument â€“ and interpreting the data â€“ falls to conservation professionals, who may or may not have sufficient scientific background to correctly apply the technique or accurately interpret the results. In 2013, the Getty Conservation Institute, in collaboration with Yale University, organized the first of a planned series of focused workshops on the fundamentals of XRF and data interpretation for art conservators â€“ XRF Bootcamp for Conservators. The selected participants were conservators from institutions without a conservation scientist on staff or with only limited access to one. Twenty participants from around the world, including Singapore, Qatar, Japan, Norway, Ireland as well as the United States, spent four intensive days of lectures, lab practicals and group projects using objects from the Yale University Art Gallery and the Yale Peabody Museum to gain a strong foundation on the scientific theory of XRF and practical, hands-on experience in its application to works of art and cultural heritage objects. This presentation will discuss how the specific needs and special circumstances frequently encountered in the analysis of cultural heritage materials can be effectively incorporated into a training and education experience to enable users to develop a deeper understanding of the technique and transitioning from being merely a user to critical thinkers.

Franz Kline's Paintings: Black and White?

Corina E. Rogge, Maite Leal, Zahira Bomford

The Museum of Fine Arts ,Houston's collection of major New York School paintings includes iconic works by Franz Kline (1910-1962), one of the defining artistic personalities of Abstract Expressionism, who worked concurrently with his friend Willem de Kooning, and also Jackson Pollock, both key artists of Abstract Expressionism in New York. These artists rejected traditional materials and embraced modern, inexpensive alternatives (house paint, Ripolin, Proxylin, acrylics), simply because these materials were new, contemporary and free from the historical association of representative art with traditional artist's oil paints. The challenge to tradition inherent in their images went hand in hand with abandoning concerns about traditional qualities in the materials they employed. The conservation community is uniquely poised at a moment in history when the physical materials that make up iconic Abstract Expressionist works are beginning to show failure. Never before has it been possible to study the physical realities of works of art at such a sophisticated level, and our investigations have identified mechanisms of failure, and informed the parameters of material integrity and treatment possibilities for our paintings by Franz Kline. Our project began with the urgent need to stabilize the badly flaking, fragile paint layers of Wotan, Kline's watershed piece of 1950, painted originally on canvas, but early in its life mounted onto Masonite (140 x 202 cm). The material history of this work, including early damages and treatments, has been reconstructed, and formed the basis for determining treatment strategy. Although prior work on later Kline paintings suggested that zinc soap formation was a key degradation process, scientific analysis (FTIR, XRF, Raman, optical microscopy, x-radiography, infra-red reflectography, ultraviolet fluorescence) suggests that while zinc pigments are present and contribute to the ageing characteristics of the paint layers in Wotan, other processes are equally, if not more significant. The extreme fragility of Wotan led us to undertake technical examination and assess condition for two other paintings by Franz Kline: Orange and Black Wall, 1959 (170 x 367 cm) and Corinthian II, 1961 (202 x 272 cm). These paintings, both unlined and on canvas, are in very different states of stability. Orange and Black Wall, like Wotan, exhibits persistent cracking, interlayer cleavage and may no longer travel. In contrast, Corinthian II is stable and in very good condition. Analysis indicates that this difference in condition mainly arises from contrasting paint-layering techniques, resulting in subtle but critical structural differences. In combination with the studies on Wotan, we may conclude that Kline's choice of materials and the method of their application both contribute significantly to the relative stability or fragility of his paintings. This paper provides a timely contribution to the on-going dialogue about technical study, treatment history and current treatment desiderata for modern paintings. Broader issues such as balancing the values of aesthetic and material preservation and re-treatability in the specific territory defined by artists like Kline and his contemporaries are also discussed.

A Hidden Blue Period Portrait by Pablo Picasso and the Alteration Mechanisms of Cadmium and Arsenic Sulfides: Synchroton-Based Methods for the Interpretation and Preservation of Paintings

Jennifer Mass

Despite extensive research into Pablo Picasso's working methods and materials, as well as detailed analyses of a handful of his later paintings, comprehensive technical analysis of a work from his Blue Period has not been carried out. The Blue Room (1901, The Phillips Collection, Washington, DC) has been known since the 1990s to have another painting, a portrait, beneath its presentation surface. This presentation will describe results of a wide-ranging analysis of The Blue Room, including combined results from portable x-ray fluorescence (XRF), Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy x-ray microanalysis (SEM-EDS), and synchrotron-radiation (SR) based XRF mapping of the entire painting. The goals of these measurements were to determine the elemental distribution of the combined paintings, and the feasibility of distinguishing features of the presentation surface and the hidden work. Numerous features of the buried portrait are identifiable in the XRF maps, which, along with hyperspectral imaging, are assisting in the ongoing interpretation of this painting. Cadmium carbonate (CdCO3) has been identified in the altered cadmium yellow (CdS) paints found Impressionist, early modernist, and post-Impressionist paintings. When it is concentrated at the surface of the paint layer, CdCO3 appears to be the result of the photo-alteration of CdS. However, in other cases CdCO3 is distributed throughout the thickness of the paint layer. CdCO3 is highly insoluble (Ksp of 1.0 ×10-12) and would not be expected to migrate from the painting's surface. Plahter et al. have recently proposed that CdCO3 is present in cadmium yellow paints as residue from the indirect wet process synthesis of CdS using CdCO3 and Na2S.[1] To determine the role of CdCO3, as well as cadmium oxalates and sulfates, microspectroscopy and microdiffraction of altered and unaltered cadmium yellow samples from Henri Matisse's 1906 Flower Study (The Barnes Foundation, Philadelphia, PA) were carried out. X-ray fluorescence mode allowed precise mapping of elemental distribution, and Full Field X-ray Near-Edge Absorption Structure (FF-XANES) allowed mapping the chemical speciation of cadmium and sulfur. The XANES data support Plahter's hypothesis for the 1906 still life. Yellow orpiment (As2S3) and red-orange realgar (As4S4) are arsenic sulfides that have been used as pigments since antiquity. Orpiment becomes paler and colourless upon exposure to light, while realgar turns bright yellow. A photo-oxidation process involves the conversion of orpiment to colorless arsenic trioxide (arsenolite, As2O3) and realgar is altered to pararealgar (As4S4, an isomer of realgar), and then eventually to arsenic trioxide. Here, we also report on this transformation and characterization of the reaction products, based on investigation of two very different works of art from early 18th century: Still life with five apricots by the Dutch master Adriaen Coorte (1704) (Royal Picture Gallery Mauritshuis, The Hague, The Netherlands) and an early American polychromed chest on stand attributed to Charles Guillam painted in Saybrook, Connecticut between 1710-1727 (Winterthur Museum, Winterthur, USA). The μXANES identification of further degradation products of realgar will be presented, in addition to their subsequent mobility in different paint systems. 1. Plahter, U. and B. Topalova-Casadiego. Cadmium Yellow in "The Scream" painted by Edward Munch. in The National Gallery Technical Bulletin 30th Anniversary Conference. 2011. London: Archetype.

Investigating Softening and Dripping Paints in Oil Paintings Made Between 1952 and 2007

Ida Bronken, Jaap J. Boon

Modern and contemporary art collections show an increasing number of paintings with softening oil paints and even drip formation. We have investigated paintings made in Paris during the 1950's by J-P Riopelle and P. Soulages but paintings from their contemporaries like G. Matthieu and P. Borduas also show softening paints and large drips. We are also investigating more recent dripping paintings by Van Hemert (NL), Walls (Irl), Meese (D) and Tal R (DK). These latter paintings first seem to dry properly but after about 7 years some thicker applied paints begin to "melt" and form puddles and drips of exudate. We do not know when the paintings from the 1950's painters began to show drips. One oil painting by Soulages from 1960 that was received as donation in 1965 by the Art Institute of Chicago, was seen in storage to have drips in 1992. Analysis together with the visual examination and experimental treatments of several case studies has increased the understanding of how many different physical changes in the paint are related to the softness of the medium. Even matt and cracking paint can be developing from the softness of the paint medium. There is ample evidence from a number of paints studied by mass spectrometry that the exudates are rich in polar fractions with triglycerides with moieties of mid-chain oxygen-functionalised stearic acids and azelaic acids. Remarkably they all have these specific chemical features in common. Paints where polar fractions are phase separated and depleted show an increase in saturated compounds. These observations led to the hypothesis that exudation is caused by a loss or absence of anchor sites for the acidic fractions that develop over time. The practice of using semi drying oils in the last decades is possibly another cause of poorly cross-linked fractions that may phase separate. In the paintings by Van Hemert, the cause of dripping of one kind of paint was linked to poor quality aluminium soaps used as additive. The polar exudate is strongly fluorescent, and we think that this phenomenon is often misinterpreted as pointing to a local varnish. By documentation and analysis showing the difference between a local varnish and polar exudates we hope that more cases of soft paint will be identified. Another striking feature of weeping paints is their complete solubility in polar solvents like ethanol and acetone. Binding weeping paints implies a repair on the molecular level of the superfluous polar fractions by addition of alkalinity in the form of metal ions with the potential of coordinating multiple acid groups. Traditionally this role was fulfilled by lead present as drier or in the form of lead containing pigments like lead white. We will be reporting on experimental treatments with lead II acetate and europium III acetate introduced from the surface using various methods on the pink dripping paint in a painting by Van Hemert and drip material from one Tal R painting. We report some success but a lot of fine-tuning of the methodology is required.

Overview of the CCI Lining Project: Do Linings Prevent Cracking and Cupping in Paintings?

Debra Daly Hartin, Eric Hagan, Mylene Choquette, Stefan Michalski

The goal of the CCI Lining Project, undertaken in phases since 1983, has been to understand the balance between the stresses in a lining and the stresses in the oil painting it presumably supports, as well as to observe and understand the ability of the lining to reduce cupping and cracking. In the early 80's, new materials and new techniques emerged to address the disadvantages of previous structural treatments. At this time, we asked ourselves "Are these materials doing what we think they are doing?" Can a fabric lining dominate stiffness in a lining/painting composite, can it prevent cracking during fast events such as shock, can it help during daily and seasonal RH and temperature changes, and will it continue to support the painting for many years? We have reported data and conclusions as they emerged since 1987. All results have been placed in the context of standard viscoelastic polymer mechanics. In the final phase of testing (2011-2014), a completely redesigned stress relaxation measuring apparatus was used, much more precise and automated than the first system. Samples included an unlined model oil painting and linings on linen, multifilament polyester and sailcloth, using a flocked Beva 371 nap-bond adhesive and an impregnating wax-resin adhesive. A small initial strain was applied to the samples and stress monitored over several days. Five climate conditions were tested: 21ºC/50%RH, 21ºC/10%RH, 5ºC/50%RH, -10ºC/50%RH, 35ºC/50%RH. These data were combined with the earlier 16 year room temperature data to build master curves of the stress relaxation over a range from milliseconds (relevant to shock and vibration) to decades. Measurements were also made of the response of lined paintings to rapid RH changes of ±10%RH and ±20%RH, held for periods of 1 hour, 4 hours, and 12 hours. This paper will focus on the main conclusions from the conservator's point of view and will discuss the data in terms of the implications for the effectiveness of linings, both past and future. Of the linings tested the sailcloth was the only one to provide significant support and it will maintain this support over many years. A sailcloth lining will prevent overstretching of the painting during initial stretching and provides support at cold temperatures and during shock and vibration. In periods of low RH, however, the sailcloth contributes proportionally less support to the painting. Wax-resin linings provide significant support during initial stretching and during shock and vibration, but the support does not continue over the long term. Wax-resin linings reduce the response of the painting to RH fluctuations. Single layers of linen or multifilament, woven polyester do not provide support to the painting as they are never as stiff as the paint and ground layers. The value of the data in building our understanding of the role of RH and temperature in the cracking of paintings in general will also be briefly summarized.

A Science/Conservation Collaboration: The Introduction of New, Low Molecular Weight Resins

Jill Whitten, Robert Proctor

In a 20-year collaboration the authors and René de la Rie (formerly Head of Scientific Research at the National Gallery of Art, Washington, DC) have been sharing information and techniques about the testing and uses of new low molecular weight resins for varnishing and retouching. Dr. de la Rie is invited to share his research all over the world and he realized many years ago that conservators were more likely to use new products if they were given a few days of discussion and hands-on experimentation with new materials. The workshops have been a fruitful collaboration and opportunity for learning and sharing in ten countries and three continents. The presentation will be an overview of the workshop curriculum and the difference it has made in our profession as the resins and solvents we use have become available or disappear through changes in manufacturing.

Something Rich and Strange: The Conservation and Study of Jackson Pollock's Sea Change

Nicholas Dorman, Alan Phenix, Wendy Lindsey

Jackson Pollock's Sea Change is one of very few paintings by this seminal figure in public collections in the Northwestern USA. Painted in 1947, Sea Change was one of a group of works marking Pollock's departure from brushwork and the colorful symbolic abstractions of 1946, in favor of a new method of painting. Francis O'Connor described this moment as Pollock's "first sustained exploration of the pouring techniqueâ€• . One characteristic that makes Sea Change particularly fascinating is the fact that it contains evidence of Pollock's earlier style "submergedâ€• beneath his newly embraced technique. Close examination of the painting reveals an extraordinary surface topography of colorful brushed patterns and forms that were later obscured by a dense web of scattered gravel and poured black and metallic paint. In the seven years leading up to Pollock's death, Peggy Guggenheim made a remarkable series of gifts of the artist's paintings to museums and colleges across America and around the world. Seattle was one the beneficiaries of Guggenheim's generosity, with Sea Change being pledged to the Seattle Art Museum in 1955 and formally entering the museum collection in 1958. By the 1970s, the inherent fragility of the painting had become apparent, with losses of gravel, and canvas distortions caused by the flimsy strainer and contracting, thick paint. Concerns about the deterioration led to conservation treatment in 1977, including attaching the painting to a honeycomb panel support and varnishing with an isobutyl methacrylate coating. The objective of the recent treatment of Sea Change was to remove the varnish to bring the surface closer to that which was crafted by Pollock. Varnish removal tests revealed that Pollock's colors from the first stage of painting are characterized by a rather lean, matte surface, whereas the overlying poured metallic and black paints were more medium-rich and glossy. Extensive tests for varnish removal were undertaken with conventional aromatic solvents and naphthalene depleted Exxon solvent ND150 and these tests will be described in the presentation. A small number of samples were taken as cross-sections from the tacking margins and the edges of gravel losses on the face of Sea Change. Samples were analyzed at the Getty Conservation Institute and the results enabled us to reconstruct Pollock's palette for both campaigns of painting. These samples also elucidated the layer structure and provided information on the painting's binding medium. The concurrent J. Paul Getty Museum/GCI treatment and studies of Pollock's Mural provided invaluable comparative material. The technical study considerably enhanced our understanding of the way Pollock produced Sea Change. In the past, our characterization of the way Pollock executed drip paintings may have been defined by notions of automatic process and a spontaneous gestural technique. Close study of this painting and recent studies of other Pollock paintings, however, advances our understanding of the degree to which he also incorporated less spontaneous approaches into his array of working methods. Here, Pollock re-worked an existing paint surface, revealing some earlier forms and obscuring others, intervening with a scattering of pebbles and poured color and then, finally, refining the composition with carefully positioned spots of artists' color applied straight from the tube. This collaborative treatment and research project resulted in the recovery of a more appropriate surface for Sea Change and the technical study enhanced understanding of this important moment in Pollock's career, as he took his canvas off the easel and onto the floor.

2016 – Research and Technical Studies Specialty Group Presentations

Binders and Pigments Used in Traditional Aboriginal Bark Paintings

Narayan Khandekar, Dan Kirby, Georgina Rayner, Katherine Eremin

In conjunction with the upcoming exhibition Everywhen: The eternal present in Indigenous art from Australia, the Straus Center for Conservation and Technical Studies, Harvard Art Museums has conducted a major survey of the pigments and binders used in traditional Aboriginal bark paintings from Arnhem Land, Groote Eylandt, the Kimberley and the Tiwi Islands. Paints were analyzed for: 1. binding media using Fourier transform infrared spectrometry and pyrolysis gas chromatography mass spectrometry and 2. pigments by laser ablation-inductively coupled plasma-mass spectrometry to determine if an elemental fingerprint could be identified. Approximately two hundred samples from fifty paintings were analyzed from: Museum Victoria; Ian Potter Museum of Art, University of Melbourne; National Gallery of Australia; Art Gallery of New South Wales; Australian Museum; National Gallery of Victoria; Macleay Museum, University of Sydney; Peabody Museum of Archaeology and Ethnology, Harvard University. The following art centers provided standard pigments and binders: Buku Larrnggay Mulka, Yirrkala, NT; Tiwi Design, Bathurst Island, NT; Warringarri, Kununurra, WA. Binders were present in 77% of the samples we analyzed. No proteins, waxes, fats or blood were detected as a binder. The presence of nitrocellulose on Groote Eylandt paintings was connected to records from the 1948 expedition linking the condition of the paintings to an application of Duco to consolidate them. Orchid juice was chemically identified as a binder in a painting for the first time and was identified in the oldest bark paintings dating to pre-1878. The use of a variety of blacks from Groote Eylandt was identified as originating from natural manganese ore, dry cell batteries and charcoal. The differences in elemental fingerprints between ochres of the same location, as well as from painting samples indicates that more studies are required on a local level to determine the source and movement of ochres.

Characterizing the Age of Ancient Egyptian Manuscripts through Micro-Raman Spectroscopy

Sarah Goler, Alexis Hagadorn, Angela Cacciola, David Ratzan, James T. Yardley

The dry climate of Egypt has preserved thousands of handwritten documents and books, from the Old Kingdom to the Middle Ages, that can provide insight into our understanding of ancient cultures. Unfortunately, in most cases the dates of these manuscripts are unknown, although several document types bear precise dates, often to the day. For the undated manuscripts, the only current scientific method of estimating the date of writing is radiocarbon dating, but these measurements are destructive and cannot be practically used to date the media as separate from the support. In contrast, micro-Raman spectroscopy, a non-destructive light scattering technique, can be used to distinguish physical and chemical properties of materials. We have discovered that, for a study of well-dated ancient Egyptian papyri covering the date range from 300 BCE to 900 CE, the Raman spectra (25 to 40 measurements on each manuscript) of black ink all show the characteristic spectrum of carbon black materials. The spectrum of carbon black is characterized by two broad features, the G and D bands. The G band at 1585 cm-1 is a Raman allowed transition that arises from the E2g in-plane vibration of sp2 bonded carbon. The D band is a forbidden Raman transition that occurs when the lattice symmetry is broken. The D band at approximately 1350 cm-1 is associated with disorder, vacancies, crystalline edges, etc. The broad spectroscopic features are indicative of crystalline and amorphous carbon. We observed the carbon black spectra exhibit systematic change as a function of manuscript date. This observation is unexpected given the dates of these papyri cover a 1,200-year time span and the fact that each manuscript has a unique provenance, archeological, and storage history. We conclude that, over this time-period, black ink pigments in Egypt were manufactured using similar processes. We attribute the systematic change we observe in the Raman spectrum to two concurrent oxidation processes: slow oxidation of the crystalline carbon and faster oxidation of the amorphous carbon. The changes we observed are well characterized by models for carbon black Raman spectra that relate the relative intensity of the D to the G peak to defect density in accordance with oxidation. Oxidative degradation must proceed relatively uniformly over time to alter the Raman response of the material, providing a direct experimental indicator for manuscript age. Using this technique, we have been able to distinguish between the Raman spectra of different carbon-based manuscript inks on ancient Egyptian documents. Most importantly, this research establishes the basis for a simple, rapid, non-destructive method for dating ancient manuscripts from Egypt as well as the ability to differentiating between modern forgeries and authentically ancient manuscripts.

Colorimetric Sensor Arrays for Monitoring Pollutant Exposure of Artwork

Kenneth Suslick, Herant Khanjian, Kristen McCormick, Maria LaGasse, Michael R. Schilling

The acceptable pollutant concentration limits for sensitive artwork are generally at or below the few ppb regime: this is only ~1% of the permissible exposure limits (NIOSH PEL) required for humans. Monitoring such pollutants at such low levels is an exceptional scientific challenge, especially to do so in a cost effective fashion for a large number of locations and microenvironments (e.g., every display case in a museum). To meet this challenge, we have extended with new sensor array chemistry our already extremely sensitive and portable "optoelectronic nose" [1-4] and developed cumulative colorimetric sensor arrays. The resulting disposable sensor arrays are inexpensive, cross-reactive sensors using a wide range of chemical interactions with analytes (i.e., not just physical adsorption): an optical analog of mammalian olfaction. By digitally monitoring the change in color of each spot in the easily printed array, one has a quantitative measure of the composite response to volatiles. The use of a disposable array permits the use of stronger chemical interactions, which dramatically improves both sensitivity and specificity compared to any prior enose technology. Importantly the sensor array has been specifically engineering to be insensitive to humidity changes. A new and highly compact reader (the size of a deck of cards) for these arrays based on the color contact image sensor (CIS, used for portable business card and paper scanners) was used for these studies. We have broadened these studies by the use of cell phone camera imaging and made trial experiments in the monitoring of artwork from the Disney Animation Research Library exhibition in Beijing and Shanghai in order to monitor pollutant exposure both during shipping and during exhibition. This exhibition, "Drawn from Life: the Art of Disney Animation Studios" features animation drawings, story sketches, layouts, backgrounds, and concept art spanning the 90 years of the Walt Disney Animation Studio's history. Sensor arrays were used to monitor both exterior and interior environments of passepartout frames at the exhibition and inside the shipping crates during transport. 1. Rakow, N. A.; Suslick, K. S. "A Colorimetric Sensor Array for Odor Visualization" Nature, 2000, 406, 710-714. 2. Suslick, K. S. "Synesthesia in Science and Technology: More than Making the Unseen Visible" Current Opin. Chem. Bio. 2012, 16, 557-563. 3. Lim, S. H.; Feng, L.; Kemling, J. W.; Musto, C. J.; Suslick, K. S. "An Optoelectronic Nose for Detection of Toxic Gases" Nature Chemistry, 2009, 1, 562-567. 4. Askim, J. R.; Mahmoudi, M.; Suslick, K. S. "Optical sensor arrays for chemical sensing: the optoelectronic nose" Chem. Soc. Rev. 2013, 42, 8649 - 8682.

Combining RTI with Image Analysis for Quantitative Tarnish and Corrosion Studies

Chandra Reedy, Kevin Barni, Ying Xu

Reflectance Transformation Imaging (RTI) has become an important part of the documentation repertoire of many conservation laboratories. The ability to enhance details of surface shape and color helps in discerning surface information not otherwise easily visible. RTI is usually used to obtain qualitative data, such as reading difficult-to-see inscriptions and decorative details. We have been experimenting with combining RTI with image analysis for quantitative applications. Image analysis starts with algorithms that enhance visual separation of different features in an image and mark for analysis (in a process called 'segmentation') features of a specific color, contrast, size range, and/or morphology. Satisfactory segmentation is the core requirement for successful image analysis. Once this is achieved, a variety of quantitative data on those highlighted regions can be collected simultaneously. RTI plus image analysis is a natural coupling. Since quantitative analysis of surface features first requires the best possible segmentation, the enhanced surface detail produced by RTI is a clear advantage. One application we have been experimenting with is the use of RTI plus image analysis to obtain quantitative data on surface corrosion. The technique has been applied to coupons from Oddy tests, coated coupons artificially aged in a weatherometer, and metal sheets used for rapid corrosion tests. Oddy tests are used to assess compatibility of storage and display materials with metals found in collections. The test provides qualitative data as to whether a material is advisable for long-term use, for short-term exhibitions, or not at all. Reading the results of these exposure tests on coupon surfaces, however, can be tricky. For example, the British Museum has recommended that to reduce surface reflections from silver and copper coupons, a sheet of white paper should be held at an angle of approximately 60° to horizontal over the coupons while making assessments. Another difficulty is that control coupons themselves can change due to the elevated RH of the test. These changes have to be accounted for in making judgements about the degree of change in non-control coupons. RTI can improve the test by allowing qualitative assessments to be made under the best standardized viewing conditions. Adding image analysis allows surface effects on the controls to be subtracted from all other coupon images, and can add quantitative data on percentage of surface tarnish. We applied this process to weatherometer tests of coatings recommended for outdoor architectural brass. Image analysis gives the percentages of pitting and corrosion products present. However, using images obtained through RTI, rather than through typical photographic or scanning methods, provides more satisfactory results. We also used this approach to assess the results of rapid corrosion tests developed in industry to test the efficacy of corrosion inhibitors. Two indicators are important but cannot be assessed easily in one image: the percentage of surface area covered by corrosion products, and the degree of pitting attack, which has the effect of darkening the shiny, polished metal surface. Using the RTI viewer followed by image analysis these two indicators can be separated and quantified.

Ensuring Maximum Impact for Conservation Science

Marie-Claude Corbeil

This presentation will explore ways to achieve effective and timely integration of conservation science into conservation practice. Two key elements for ensuring maximum impact for conservation science are research conducted in a collaborative and transdisciplinary way and proper dissemination of results. Conservation science is an integral and essential part of conservation. It provides a sound basis for informing conservation activities, by expanding our understanding of the composition, aging and deterioration of heritage materials to better care for collections, by developing improved techniques for conservation treatments or by advising on the choice of conservation materials through testing and research. Technology is constantly progressing and advances in other scientific fields are soon applied to conservation science. Techniques that were once considered sophisticated and expensive, such as Raman spectroscopy and laser cleaning, are now routinely used. The sophisticated methods of today that are not easily accessible because of scarcity or cost may become part of the arsenal of conservation scientists in a few years. However, conservation science remains expensive, especially if one wants to take a leadership role in this field. Considering the many issues that need attention, an efficient approach is to join forces in research to find practical solutions to key issues, and to ensure that work carried out for one single institution ultimately benefits the entire community through effective sharing of knowledge. Drawing from the author's professional experience in the context of the Canadian Conservation Institute and her knowledge of the profession, examples of work carried out on different types of objects will be used to show how research projects are designed to maximise benefits so that conclusions are applicable to other objects or collections, and how projects undertaken to answer a specific question from a single museum can generate data that, once compiled, can provide a wealth of information to the broader museum community. The presentation will also discuss strategies to involve stakeholders in defining research objectives and methodologies and to ensure active collaboration with the communities using the research results.

Imaging of Analog Materials and Machine-Dependent Formats

Fenella France, Meghan A. Wilson, Peter Alyea

The utilization of non-invasive imaging techniques to capture preservation and heritage content information from a range of analog materials is becoming a common tool used in the preservation of cultural heritage. Spectral imaging expands the information that can be found outside the visible region, and by generating data-cubes of registered images, allows a range of image processing to reveal hidden content information from historic materials. While this at is of significant interest for historic materials such as paper and parchment documents, it is increasingly important for more modern materials that are considered restricted in being machine-readable or machine dependent for viewing. For example, a range of illumination modes has been used to capture high quality images from photographic materials such as negatives without any traditional processing. Faded information on hygrothermograph and United States Geological Survey charts with historical environmental data and fugitive inks can also be captured, providing more information about degradation processes of specific materials within different environments. This emphasizes the need for capture of analog materials of various materials requiring different illumination and imaging parameters, including z-plane imaging. Often the range of materials are diverse but supporting documentation for scientific studies. Two and three-dimensional imaging (2D, 3D) provides additional advantages for the capture of information from modern media carriers that are considered machine-dependent, but are easily damaged by the stylus, needle or other play component. In collaboration with Lawrence Berkeley National Laboratory the Library has been integral to the development of the IRENE system "Image Reconstruct Erase Noise Etc." a non-contact imaging system using a laser to image the surface of lateral grooves of audio disc carriers of sound recordings. Further 3D confocal imaging captures the vertical grooved information on materials such as fragile wax cylinders and field recordings, materials that would be potentially damaged if attempts were made to capture using traditional methods. The imaging system has been modified to capture information from other historic sounds recordings such as dictabelts. For both imaging systems, spectral and IRENE a focus on standardized processing to expand the information captured has been critical. For spectral imaging, a range of software packages have been assessed and standard processing techniques compared to assure high quality and accurate data is being captured from these imaging systems. The standardization of image processing and assurance of accuracy without creation of artifacts is paramount to the utilization of imaging technologies and digital derivatives for heritage science.

Infrared Imaging of Art Objects: Is It as Easy as It Sounds?

Tom Tague

The non-invasive in-situ infrared analysis of art objects was first accomplished with single point portable analysis systems. A small FTIR spectrometer could be brought to the object of interest and a quick analysis performed. This allowed objects to be analyzed without the need of removal from the gallery or removal of small samples from the object. The analysis is accomplished by illuminating the sample with infrared light and collecting the signal reflected by the sample. A natural extension of this method would be the replacement of the single detector element with a many pixel array detector such as a Photovoltaic Mercury Cadmium Telluride (PV-MCT) focal-plane array (FPA). FPA's have been used for many years in the remote sensing of airborne chemicals, hazardous material, and spilled liquids .2-5 The conventional remote sensing infrared spectrometer with a single detector records the spectrum from a single field of view in seconds, and in contrast imaging spectrometers acquire thousands of spectra per second. As the pixels from state-of-the-art FPA detectors are small, microscopic data can be collected at high magnification over small areas or larger areas can be analyzed with less resolution. Such analyses can be accomplished in passive or active modes of analysis. Spatial and spectral information may be combined in order to improve the determination of chemical distribution. Art objects present unique challenges to the remote measurement concept. The objects typically do not emit a signal strong enough for passive detection and the introduction of a high temperature source could potentially damage the object in question. Also, traditional SiC sources were designed to illuminate small areas and had too low a power output to be useful for large fields of interest. Objects can also be irregular in shape. A preliminary study of a variety of art objects has been performed to determine the feasibility of applying full-field middle infrared imaging to objects of interest. The large depth-of-field of a stand-off imaging system like the HI90 allows almost any object to be analyzed quickly and easily.

Investigation of Fogging Glass Display Cases at the Royal Ontario Museum

Helen Coxon, Jennifer Poulin, Jason Anema, Kate Helwig, Marie-Claude Corbeil

This presentation will describe the scientific investigation of fogging on glass display cases at the Royal Ontario Museum (ROM). This is a serious problem, affecting many museums around the world with post-2000 display cases. At the ROM, most of the glass panels that exhibited fogging were from display cases installed in 2005-2008 as part of a major renovation at the museum. In some instances, panels showing the heaviest fogging were situated next to panels showing very little or no fogging, and on some panels the fogging revealed conveyor belt and suction cup patterns. Initial efforts to clean the fogging from the glass using commercial cleaning products were temporarily successful, but were unable to remove persistent greasy residues on the glass. The fogging returned within a year, even after multiple cleaning treatments. The fogging occurred on both the inner and outer surfaces of glass panels, in cases with and without climate control, and in cases containing all types of artifact materials. In 2012, a project was developed and initiated by the ROM and the CCI whereby 21 panels from 16 display cases in 10 galleries were sampled on both inner and outer surfaces. Additionally, three panels exhibiting varying degrees of fogging were removed from display cases for testing. Analysis at the CCI was undertaken using several analytical techniques, including: pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS), Fourier transform infrared spectroscopy (FTIR), x-ray diffraction (XRD) and scanning electron microscopy-energy dispersive spectrometry (SEM-EDS). The composition of the glass panels was determined to be normal for soda lime glass. The fogging residues were found to be composed mainly of sodium salts of organic compounds (such as sodium lactate and sodium salts of fatty acids) and other sodium salts (such as sodium sulfate and sodium chloride). The source of the sodium in the residues was likely the glass itself. Off-gassing experiments with paints and a floor finish used at the museum determined that those products were not likely contributing to the fogging. Rather, it was concluded that the organic acids and inorganic anions that formed the salts likely originated from normal volatile organic compounds (VOCs) and particulate matter in the air. The formation of the fogging patterns on the display cases was greatly exacerbated by the presence of greasy material on the surface of the glass. This consisted predominantly of hydrocarbon lubricants that were transferred from machinery used in the manufacture of the glass and were not successfully removed before the installation of the display cases. Because of the variation in surface cleanliness, panels with a relatively high abundance of greasy material appeared to be heavily fogged while others with a lower abundance appeared to be unfogged. A cleaning protocol using Synperonic A-7 surfactant was tested on the three glass panels that were removed. SEM imaging of the panels before and after cleaning showed that a 200:1 solution of water and surfactant was sufficient to remove all traces of fogging, cleaning and manufacturing residues from the surfaces of the glass.

Looking Closer, Seeing More: Recent Developments in the Technical Documentation of Paintings

Ron Spronk

In recent years, major advances have been made in the technical documentation of art works and in the way that these data are made accessible. New on line archives have been created that significantly improve access to existing materials, for example on Cranach and Rembrandt. More innovative are the rapid developments in the fields of 3D scanning and printing; the standardization of documentation of art works; and the documentation of especially paintings and works of paper in extreme resolutions and in different modalities such as visible light, infrared, and X-radiography. These developments are increasingly impacting art history, technical art history, and art conservation, as well as museum practices and the art book publishing industry. It is also allowing specialists to create facsimiles of art works and other cultural heritage structures with unprecedented (and uncanny) precision. In this keynote presentation, I will discuss several aspects of these developments based on my involvement in recent and current projects such as Closer to Van Eyck and Even Closer to Van Eyck on the Ghent Altarpiece; Van Eyck Research in Open Access (VERONA); the Bosch Research and Conservation Project on Jheronimus Bosch; and The Hand of the Master on panels by Pieter Bruegel the Elder. Ron Spronk Queen's University, Kingston, ON, Canada Radboud University, Nijmegen, the Netherlands

Out of the Rain: Uncovering Artistic Process in Gustave Caillebotte's *'Paris Street; Rainy Day'*

Kelly Keegan, John Delaney, Pablo Garcia

Abstract

Gustave Caillebotte's 1877 masterpiece *"Paris Street; Rainy Day,"* a centerpiece of the Art Institute of Chicago's collection, was treated in 2013-14 and, along with its related preparatory drawing *"Study for 'Paris Street; Rainy Day',"* was given an in-depth examination as part of the Online Scholarly Catalogue "*Caillebotte Paintings and Drawings at the Art Institute of Chicago.*" These systematic examinations included infrared reflectography (multi-spectral, 960 to 2500 nm, and hyper-spectral, 967 to 1680 nm, 3.4 nm sampling); ultraviolet and transmitted visible and infrared photography; and photomicrography. The painting was also x-rayed and thread-counted, and the ground and pigments analyzed. These investigations led to major discoveries about the artist's working process, from his initial sketch on the sidewalk of the Rue de Turin in Paris to the execution and finishing of the monumental painting. First, the combined information from the multi and hyperspectral imaging allowed visualization of the stages of underdrawing and painted pentimenti. Most notably, the technical images exposed major changes to the right side of the composition including movement of the far right building and nearby compositional edge, and the addition of the large, rear-facing figure. But that was only part of the story. To begin, the drawn sketch, that first phase of the preparatory drawing, is so accurate in its depiction of the Parisian intersection that scholars have long speculated that Caillebotte employed an optical device. Researching the likely candidates led to collaboration and recreation of this initial step at the original site in Paris, still largely unchanged in its architecture. The most likely culprit proved to be the camera lucida, a small, lightweight drawing aid in use since its development at the turn of the 19th century. Once back at the studio, Caillebotte then clarified the perspective via a set of ruled and re-angled lines, resulting in a regularized architectural skeleton. Comparing careful measurements of the drawing and painting and overlaying high-resolution, scaled images, it is clear that the first stage of underdrawing in the painting is a direct enlargement of the preparatory drawing by a factor of approximately seven. With this answer came another question: how did he do it? There was no discernable grid or obvious method of enlargement. Microscopic indentations in the drawing, and small pinholes in the painting revealed via a high-resolution infrared capture at 2100 to 2500 nm, illuminated a possible method of transfer. A drafting tool such as calipers was used to carefully measure distances on the drawing, leaving small, almost invisible indentations. With a full-size canvas tacked to a studio wall, the enlargement process was recreated, and small tacks, placed along the horizon at strategic points, easily braced a straight edge to enable execution of the major architectural lines in linear perspective as made visible by false color hyperspectral infrared reflectograpy. After the setting was established, Caillebotte populated the scene with figures taken from a number of preparatory drawings and began to paint, constantly adjusting the composition, scraping, covering, rethinking, and repainting, until he reached the dynamic and familiar artistic conclusion.

Discovering the process of this painting was a complicated puzzle of information that included the original site in Paris, preparatory works, technical imaging and collaboration.

This is the story of our discoveries.

Our story of discovery begins with the treatment of the painting in 2013-14 by Paintings Conservator Faye Wrubel

Treatment included cleaning (at left), consolidation (top center), varnishing (lower right, with Frank Zuccari) and inpainting (top right).

Many exciting discoveries were made during and just after the treatment.

Initial findings from examinations during the treatment inspired the online scholarly catalogue.

Much of the research presented in this talk is also available associated with the individual works in the catalogue:

Caillebotte Paintings and Drawings at the Art Institute of Chicago, ed. Gloria Groom and Genevieve Westerby (Art Institute of Chicago, 2015).

https://publications.artic.edu/caillebotte/reader/paintingsanddrawings/section/491

Research for the online catalogue coincided with research the National Gallery was doing in preparation for the exhibition.

Exhibition catalogue on the left, gallery image from the National Gallery on the right

"Gustave Caillebotte: The Painter's Eye"

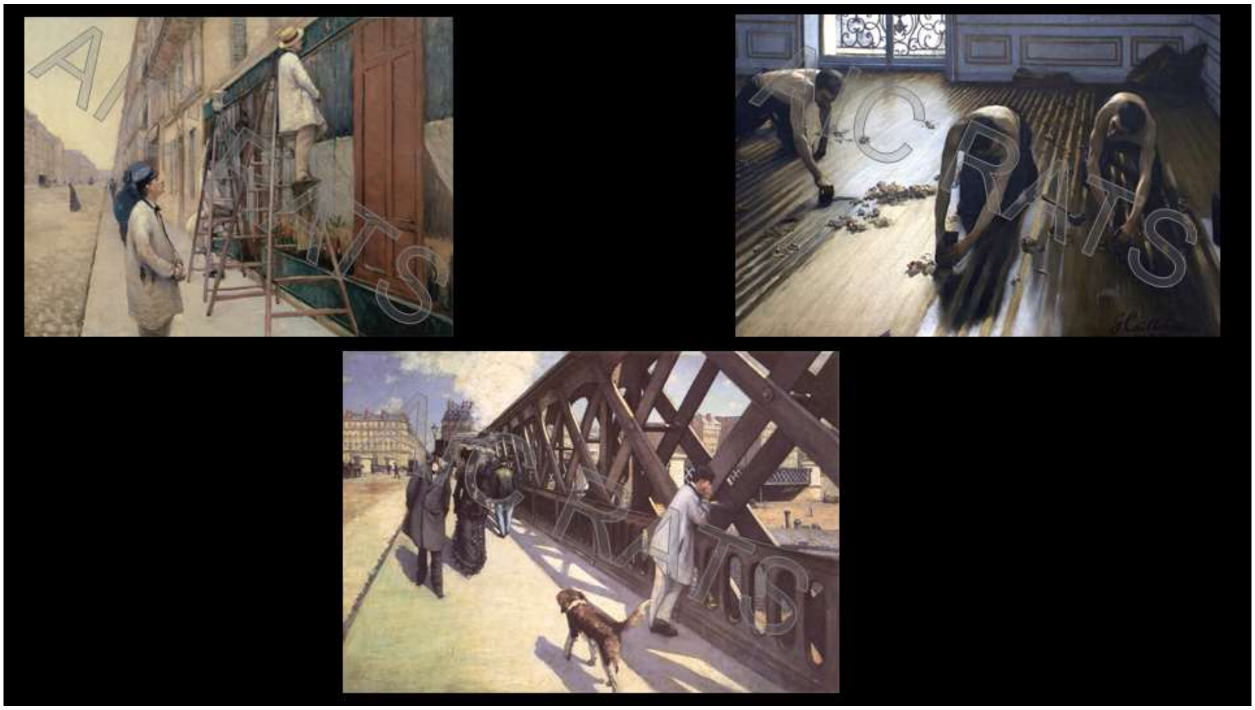
National Gallery, June 28–Oct. 4, 2015

Kimbell Art Museum, Fort Worth, TX, Nov. 8, 2015–Feb. 14, 2016

http://www.nga.gov/content/ngaweb/exhibitions/2015/gustave-caillebotte.html

http://caillebotte.kimbellart.org/

Paris Street; Rainy Day was painted by Gustave Caillebotte (French, 1848–1894) in 1877



It was the largest in an 1876-77 series that dealt with plunging perspectival views and were based in Paris.

These included (from L) *House Painters* (1877, oil on canvas, Private Collection); *Pont de l'Europe* (1876; oil on canvas; 124.7 x 180.6 cm; private collection); and *Floor Scrapers* (1875, oil on canvas, 102 x 146.5 cm, Musée d'Orsay, Paris)

Many known preparatory works for the monumental painting, including individual sketches for the figures, a few of which are shown with corresponding details from the painting.

Drawings: (left to right) *Study of a Woman with a Large Umbrella, Seen from the Back*, 1877. (Graphite on cream paper; 470 × 317 mm. Private collection); *Study of a Couple Seen from the Front under an Umbrella*, 1877. (Graphite and charcoal on buff paper; 470 × 309 mm. Private collection. Photograph © Christie's Images/Bridgeman Images.); *Study of a Man under an Umbrella Facing Right*, 1877. (Graphite and charcoal on buff paper; 451 × 392 mm. Private collection, courtesy of Brame and Lorenceau, Paris)

There is a small, painted sketch: *Sketch for "Paris Steet; Rainy Day,"* 1877. Oil on canvas; 54 × 65 cm (21 1/4 × 25 5/8 in.). Musée Marmottan Monet, Paris.

Photograph by Faye Wrubel

and this schematic architectural drawing in the Art Institute collection.

Study for "Paris Street; Rainy Day" (1877; graphite, with touches of erasing and touches of charcoal on tan, moderately thick, moderately textured handmade laid paper; 30.2 x 46.5 cm; The Art Institute of Chicago, 2011.420)

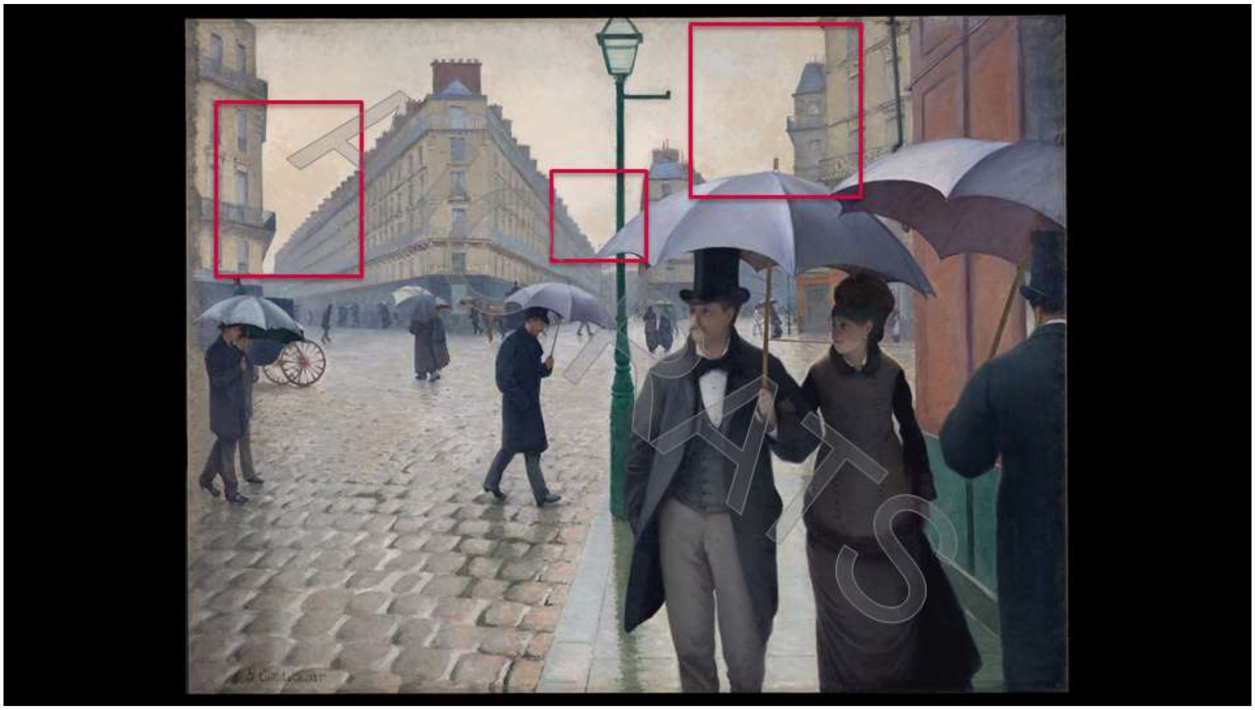
Senior Prints and Drawings Conservator Antionette Owen, seen here, examined the drawing as part of this study.

How this drawing related to both the original site in Paris and the final painting were among our major questions.

There were many early discoveries revealed by the cleaning, as discolored varnish and overpaint were removed.

Images: Faye Wrubel removing discolored varnish from the painting

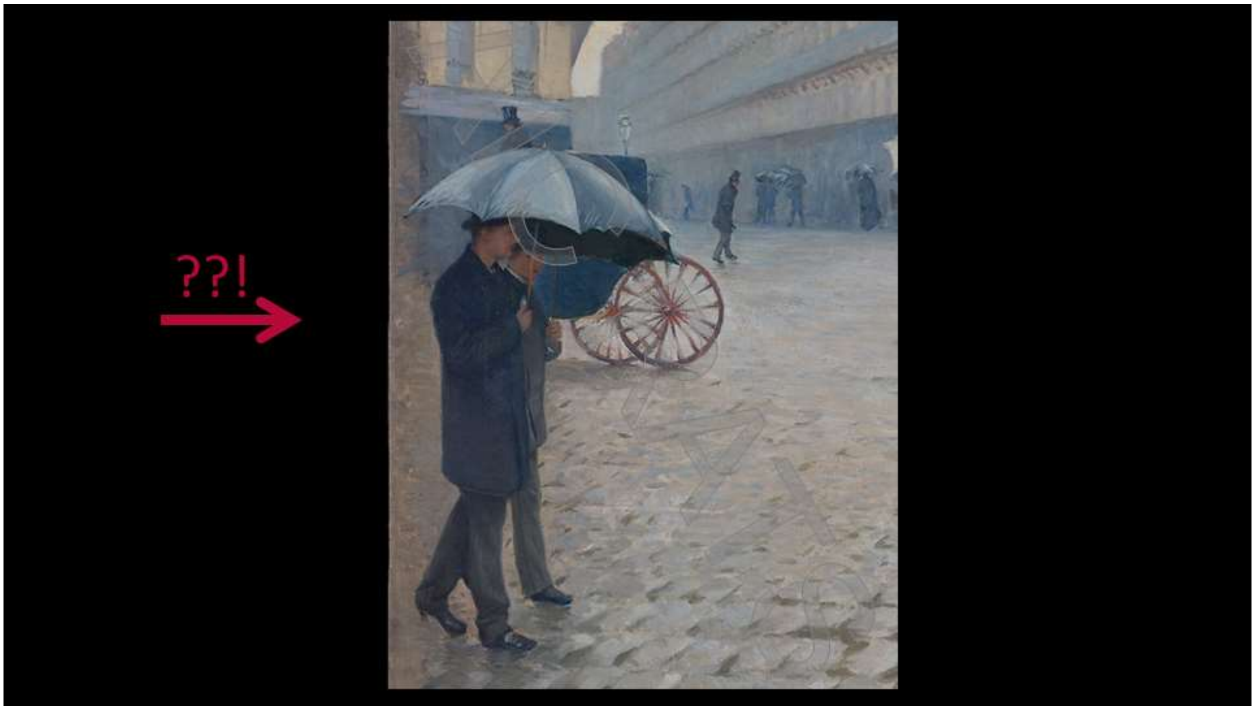
Pre-treatment image on the left shows the level of discoloration of the varnish (applied during a treatment prior to the 1964 acquisition by the Art Institute), and also that large areas of the sky between the buildings had been overpainted. The intended variation can be seen in the after-treatment image on the right.



During the pre-1964 treatment, these areas were believed to be reworked by the artist, perhaps to cover compositional changes, that had unintentionally darkened and were therefore painted out.

The presence of this variation in the painted Marmatton sketch (at right), however, suggests this was an intentional atmospheric effect.

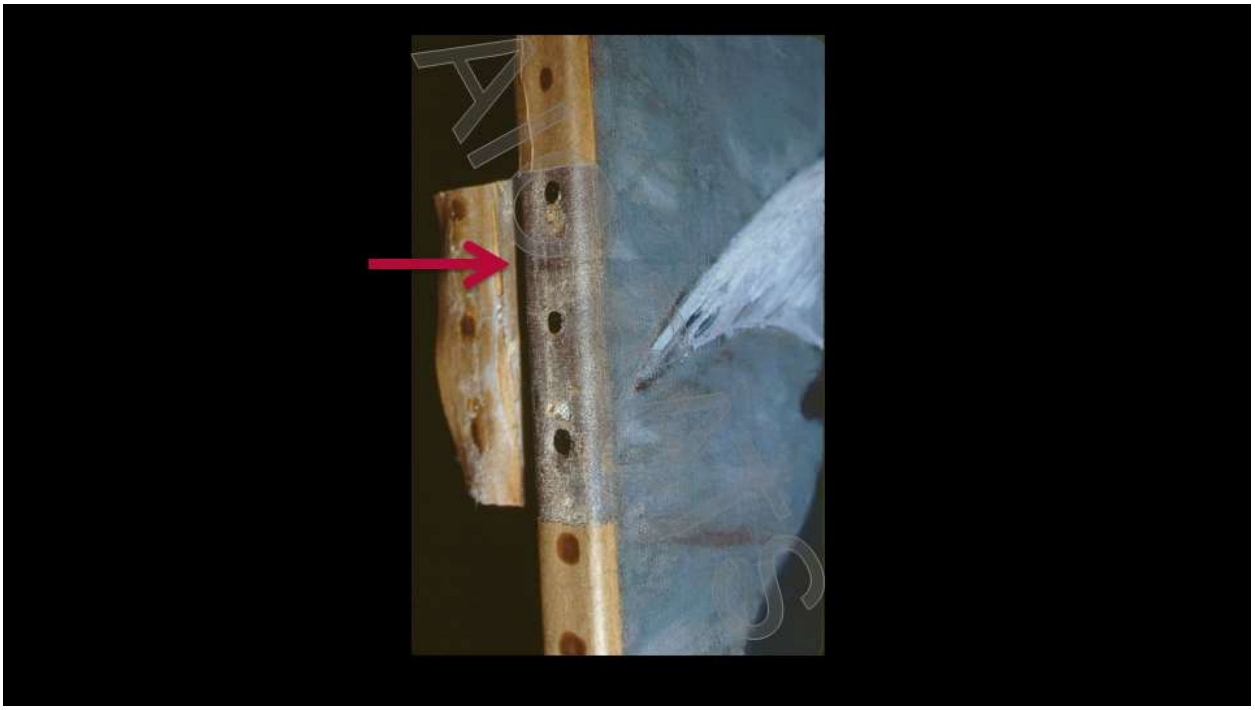
Image at left: *Sketch for "Paris Steet; Rainy Day,"* 1877. Oil on canvas; 54 × 65 cm (21 1/4 × 25 5/8 in.). Musée Marmottan Monet, Paris. Photograph by Faye Wrubel



The partially unfinished left edge had also been overpainted in the previous treatment. Removing that overpaint drew attention to the fact that this carriage has no horse.

The carriage is one of many details that seemed to end or become less defined along the still visible black painted line at left (here reinforced).

Overlaying the schematic preparatory drawing with the painting using Photoshop = the edge of the sketch matches the black line on the painting



This demarcation down the left side was the first of many clues that suggested the painting was started off the stretcher. Why else would the artist need to indicate the edges of his composition?

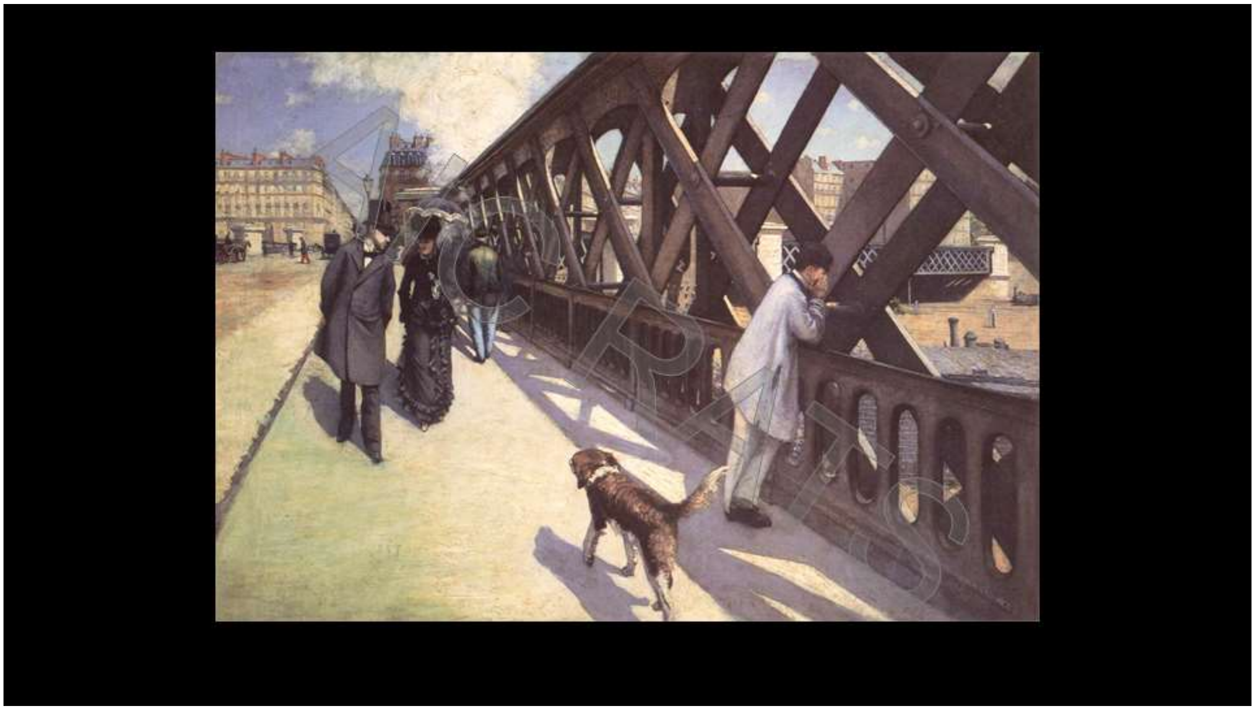
This pre-treatment image of the left edge under the paper tape reveals the dark horizon line goes off the edge of the compositional space.

The vertical dimensions were limited by the standard width of canvas available at the time (210 cm). Thread angle analysis revealed primary cusping, from industrial preparation, along the top and bottom edges. Part of the unpainted tacking margin from the industrial priming frame is also visible under the paper tape along the top and bottom edges.

Sections of canvas, typically 2–2.1 × 10 m, were prepared on priming frames, resulting in a roll of canvas that could be sold or further divided. Standard-size canvases were typically cut from these rolls and stretched individually. As the original stretcher is lost and there is no evidence of a canvas stamp on the verso, it is not clear whether Caillebotte purchased a roll of canvas and stretched it himself, or made a custom order. For discussion of commercial priming, see Don H. Johnson, C. Richard Johnson, Jr., and Ella Hendriks, "Automated Thread Counting," in *Van Gogh's Studio Practice*, ed. Marije Vellekoop, Leo Jansen, Muriel Geldoff, Ella Hendriks, and Alberto de Tagle (Van Gogh Museum, 2013), pp. 147–48. See also David Bomford, Jo Kirby, John Leighton, and Ashok Roy, *Art in the Making: Impressionism*, exh. cat. (National Gallery, London/Yale University Press, 1990), p. 46; Iris Schaefer, Caroline von Saint-George, and Katja Lewerentz, *Painting Light: The Hidden Techniques of the Impressionists* (Skira, 2008), p. 52.

Thread count and weave information determined by Thread Count Automation Project software. Thread count report (Sept. 2014) prepared by Don H. Johnson and Robert G.

Erdmann (https://publications.artic.edu/caillebotte/sites/publications.artic.edu.caillebotte/files/file_assets/tcr_B57.pdf)



Documentary evidence discovered by Caroline von St. George, at the Wallraf-Richartz & Museum Courboud, Cologne during the treatment of the *Pont de l'Europe*, suggests Caillebotte may have used framing to cover unfinished edges of his work rather than restretch the canvas.

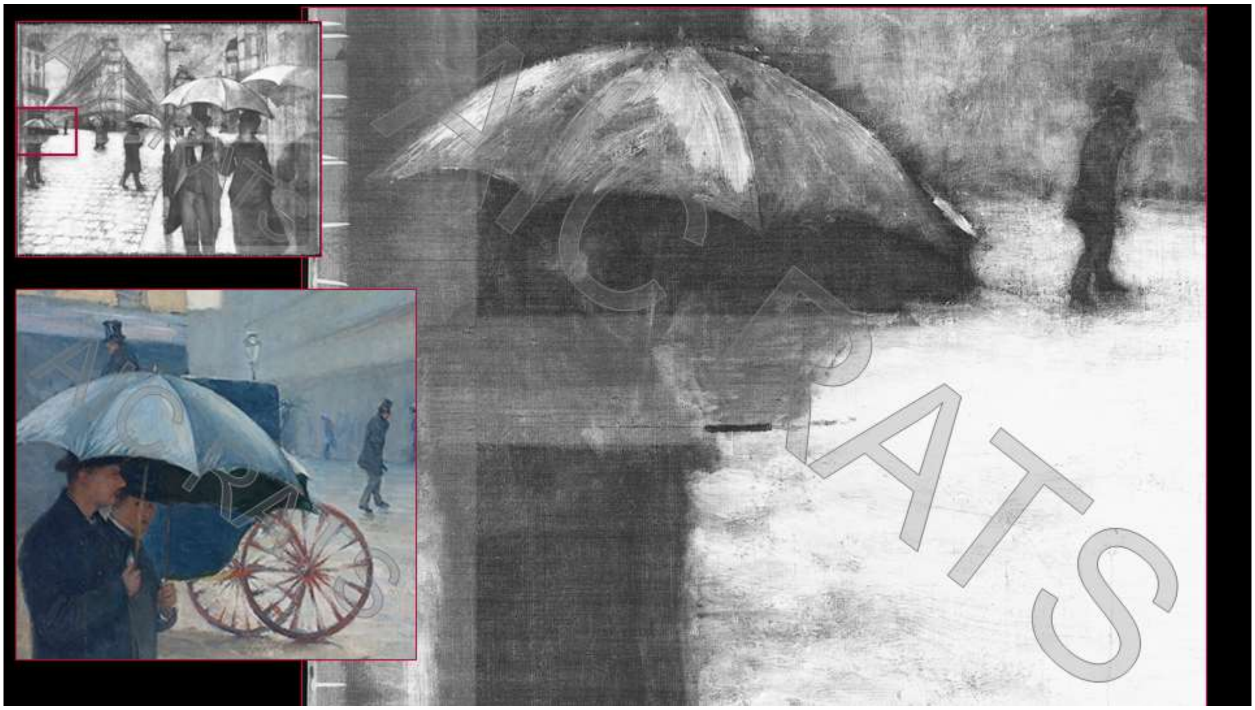
Pont de l'Europe (1876; oil on canvas; 124.7 x 180.6 cm; private collection)

[*Image removed due to copyright restrictions*]

An 1894 photograph of the *Pont de l'Europe* (1876; Association des Amis du Petit Palais, Geneva) shows the painting with what appears to be an unfinished, rough upper edge. Faintly visible in the photograph is a dark, uneven line around the perimeter of the picture; this line is the edge of the discolored varnish layer that was applied while the painting was framed and shows that, during Caillebotte's lifetime, he framed the picture such that the top edge was covered. The practice of varnishing paintings while framed was very common in this period. See Claude P. J. Ghez, Caroline von Saint-George, Iris Schafer, and Theresa Neuhoff, "Appendix: Historical Photograph and Restoration of the Work," in *Gustave Caillebotte: An Impressionist and Photography*, ed. Karin Sagner and Max Hollein, in cooperation with Ulrich Pohlmann, exh. cat. (Schirn Kunsthalle Frankfurt/Hirmer, 2012), pp. 100–01. The historical photograph is reproduced as fig. 9B on p. 101.

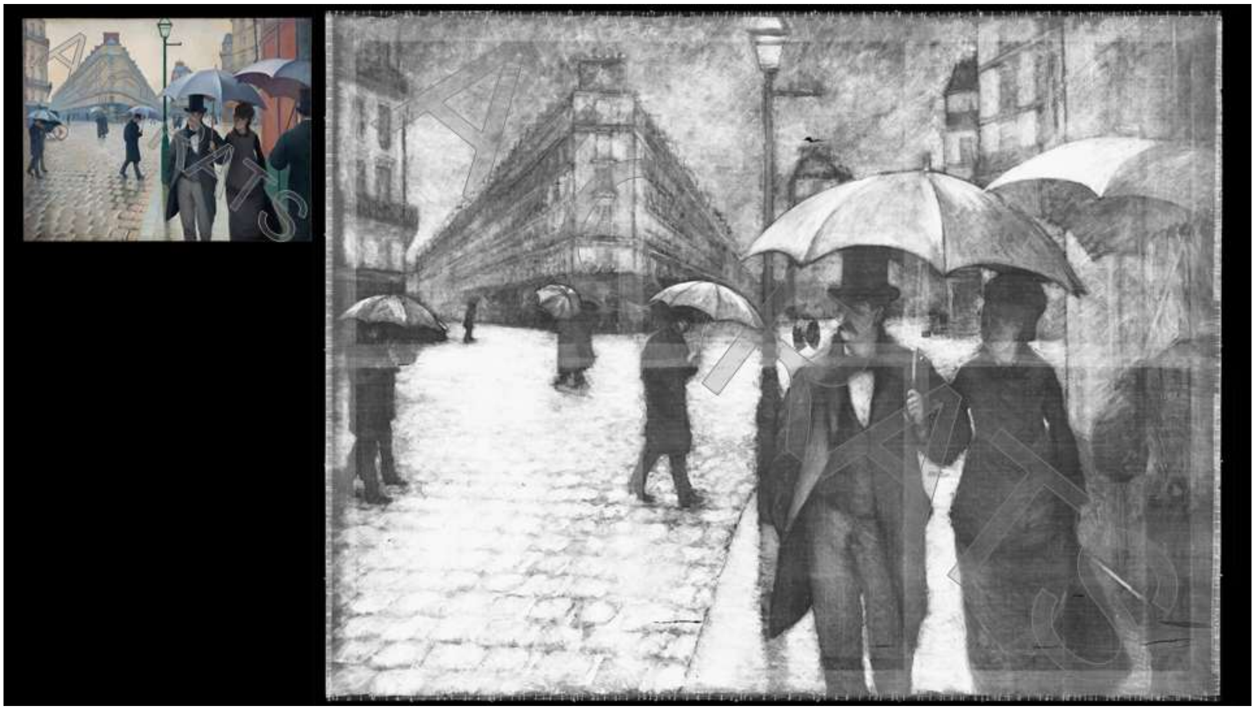
- the painting in its current frame

Framed to the black line, the horseless carriage doesn't seem so odd. The painting will eventually be reframed to cover the unfinished margin at the left.



The x-ray shows scraping in the area now occupied by the carriage, indicating it was added later (it does not appear in either the Art Institute drawing or the Marmottan painted sketch).

X-ray scans were digitally composited by Robert G. Erdmann, Rijksmuseum, University of Amsterdam, and Radboud University.



The x-ray shows many details about the artist's process:

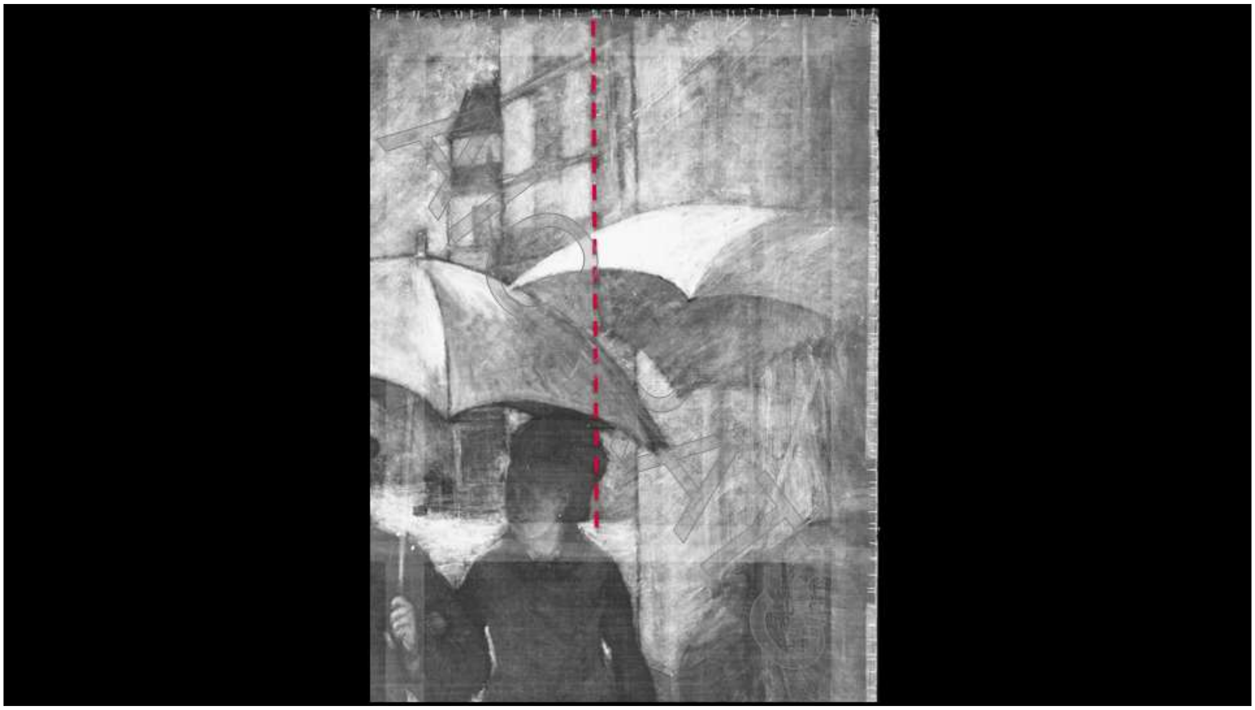
Lots of dense paint throughout, background brought in around the figures

Radio-transparent "Lines" around figs: x-ray shows evidence of drawn lines but not the lines themselves

X-ray scans were digitally composited by Robert G. Erdmann, Rijksmuseum, University of Amsterdam, and Radboud University.

Scraping on the right side of the painting also suggests compositional changes. Additionally, unlike the other figures in the painting, the far-right, rear-facing figure appears to have been added on top of the building.

Image: overall x-ray (upper left) and detail of the x-ray



There is also a faint line just left of the edge of the far right building (it passes near the drainpipe, through the far-right umbrella and just past the female figure's hair): here reinforced in red.

Image: detail of the x-ray

Looking at the surface of the painting under the microscope, it appears the salmon color of the far right building once extended further to the left and was scraped away.

Seen in this detail between the female figure's left arm and the current edge of the building.

In this detail of the area between the drainpipe and the far-right building, small hints of the salmon color can be seen under the current beige and gray building

This apparent placement of the building slightly further to the left of its current location also lines up with its placement in the Art Institute drawing (enlarged and overlaid here).

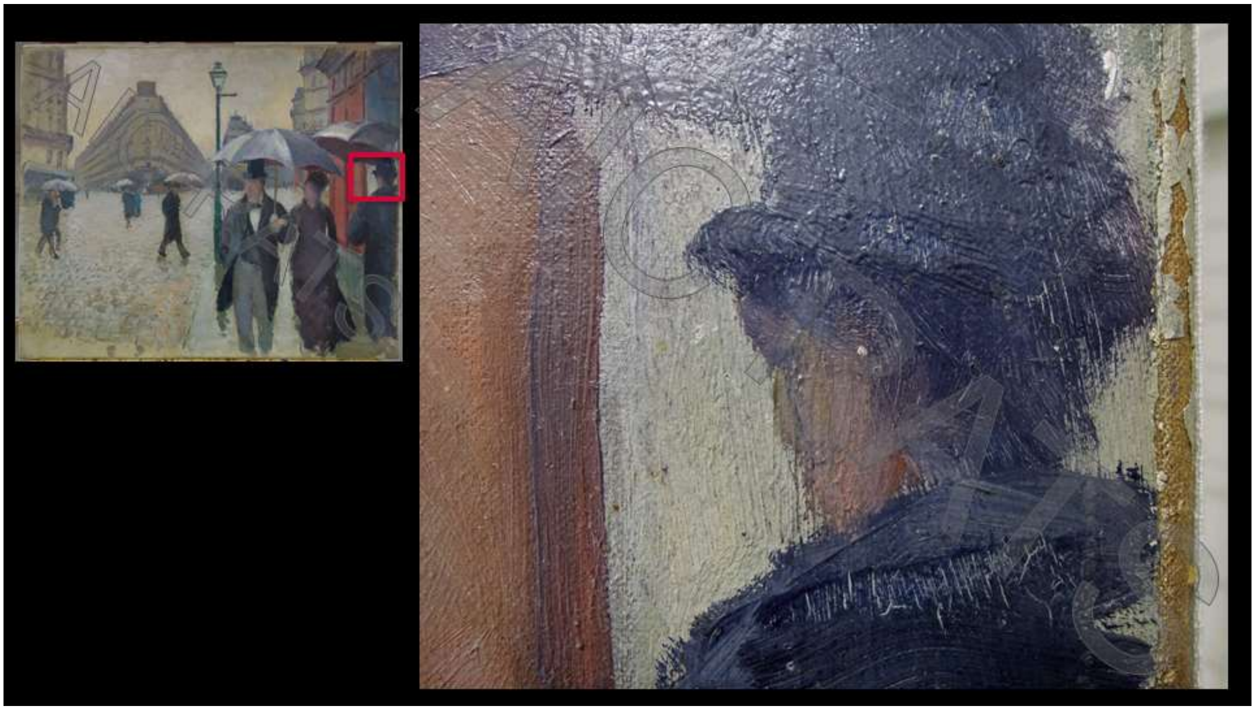
When this area of the final painting is compared with the painted Marmottan sketch, some differences become apparent:

The figures are larger with regard to their surroundings in the final painting (therefore, leaving the building in its previous location would eliminate the space between the female figure and the far right building)

Moving building appears unrelated to the addition of far right figure; seems more about creating space over female figure's shoulder

Caillebotte creates this space over the female figure's shoulder by moving the building further to the right, and then draws attention to it with the addition of the small figure (dressed in blue with a white apron, and an umbrella)

Progression of changes in the final painting = building moved first, then the far-right figure was added



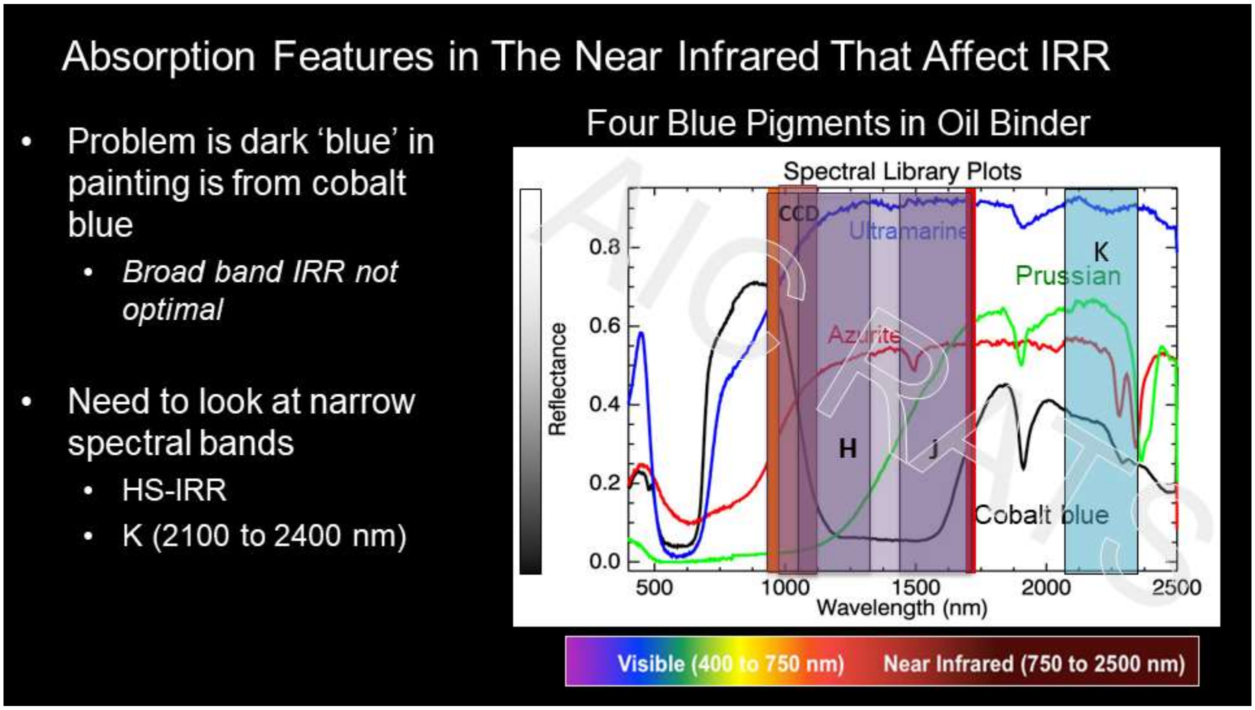
Interestingly, looking at the painted Marmottan sketch, traction on the far-right figure suggests that he was also added later.

This suggests a kind of back and forth between the sketch and the final painting.

Images: Overall (left) and detail from *Sketch for "Paris Steet; Rainy Day,"* 1877. Oil on canvas; 54 × 65 cm (21 1/4 × 25 5/8 in.). Musée Marmottan Monet, Paris. Photographs by Faye Wrubel

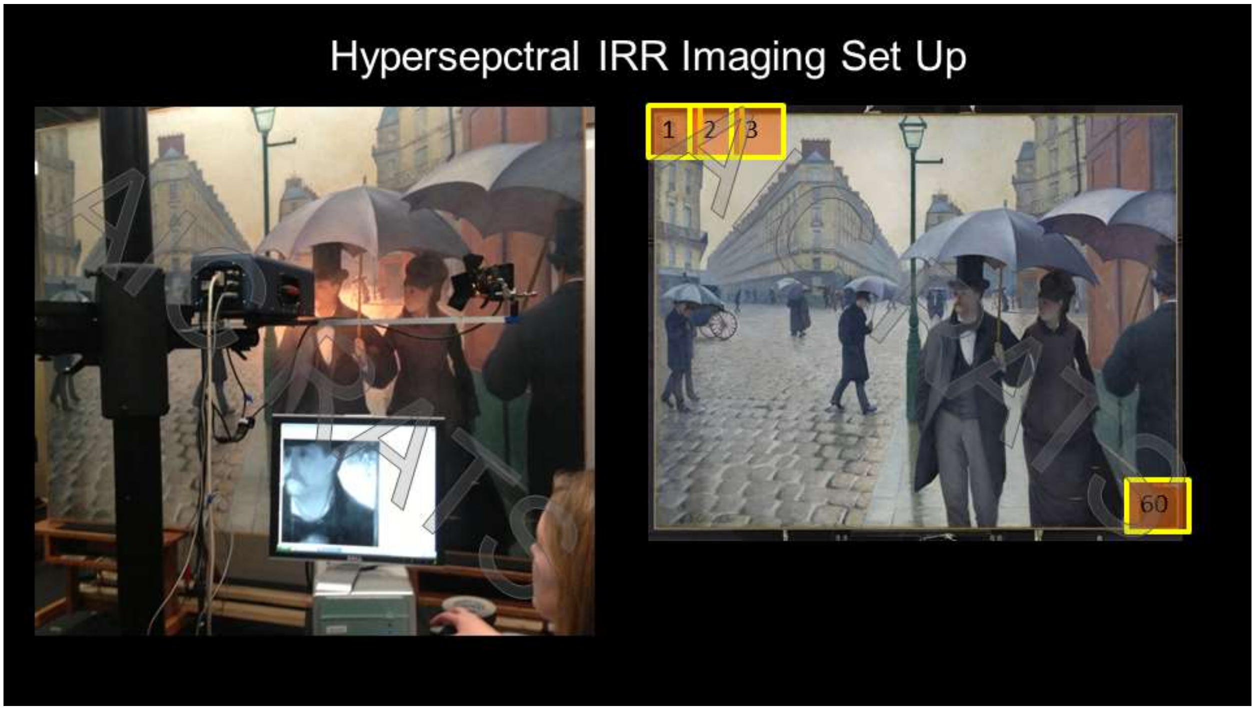
As mentioned, the early stages of this research were concurrent with research related to the National Gallery exhibition. Colleagues there were also interested in the relationships between the many drawings and the paintings. Seen here, some of these drawings are gridded as if for transfer; is there a similar grid on the painting? Initial imaging at the Art Institute found no evidence of a grid, so the National Gallery sent Senior Imaging Scientist John Delaney and Research Scientist Kathryn A. Dooley to undertake more advanced imaging.

Images: (left) . The gridded preparatory drawing for *Oarsmen* is included on the right side of a preparatory drawing for *Paris Street*; see Julia Sagraves, "The Street," in Anne Distel, Douglas Druick, Gloria Groom, and Rodolphe Rapetti, with Julia Sagraves and an essay by Kirk Varnedoe, *Gustave Caillebotte: Urban Impressionist*, exh. cat. (Musée d'Orsay/Art Institute of Chicago, 1995), p. 127, cat. 44 (ill.).; (right) a gridded preparatory drawing of the central figures



The imaging problem was complicated: the prevalence of IR-absorbing pigment cobalt blue seemed to obscure the extent of of the underdrawing. The broad band filters (H, J) are not ideal for differentiating the blue from carbon-based underdrawing. We needed further penetration (in the K filter range) and narrower filters via the hyperspectral camera.

John and Kate used the Surface Optics modified near-infrared hyperspectral camera (collects 3.4 nm spectral-band images from 960 to 1730 nm) to create a false color IR image.



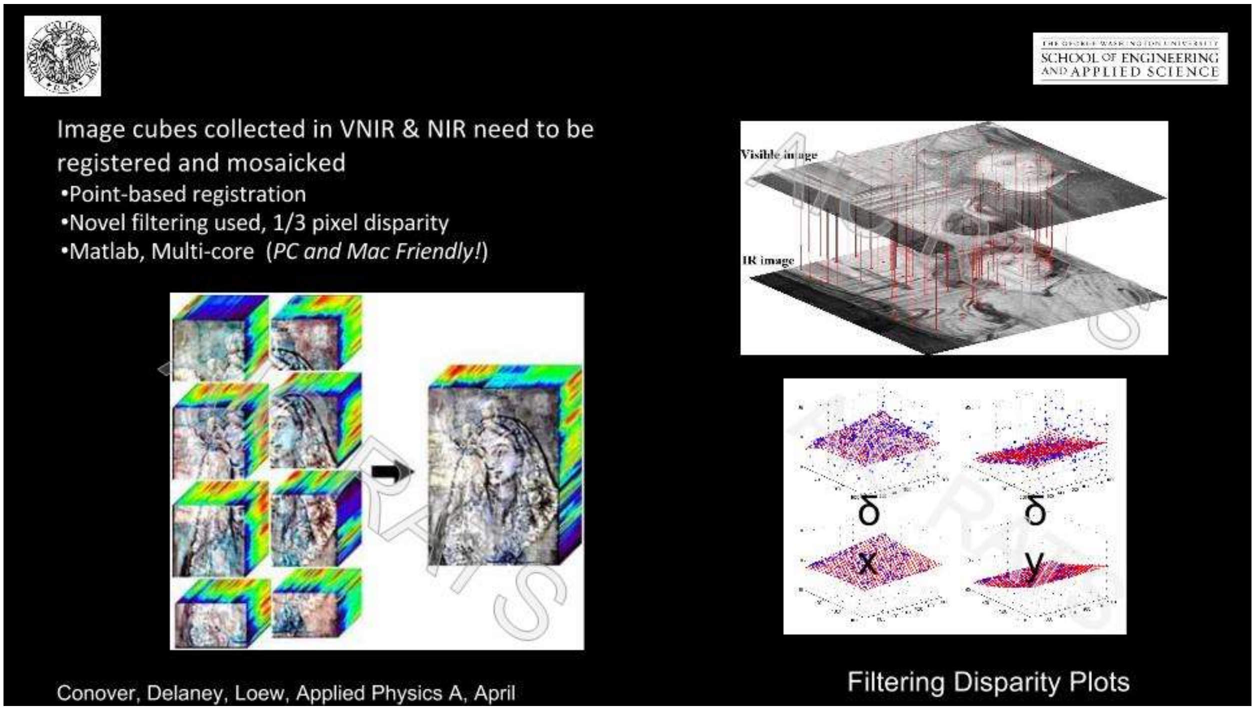
60 image cubes were captured via the hyperspectral camera

Image: False-color infrared (Surface Optics, 1.659, 1.050, and 0.976 μm); Image captured by John K. Delaney and Kathryn Dooley, the National Gallery of Art, Washington, D.C.

One can easily distinguish between the carbon-based underdrawing (seen as reddish here) and the subsequent paint.

A brief explanation of false-color infrared: Unlike a true-color image, a false-color image depicts objects with colors arbitrarily assigned based on the sensitivity of specific materials at certain energies in the spectrum. A false-color image is created by combining information from three individual images input into each of the red, green, and blue (RGB) channels of a color image and enables detection of specific features that are not otherwise apparent. False-color imaging usually relies on at least partial information from outside the visible spectral range (300–700 nm), such as infrared. As opposed to a normal, grayscale infrared image taken with a broadband filter (each covering approximately 200–300 nm), the false-color infrared images created in this study combine information from different spectral bands captured with a hyperspectral camera, which simultaneously acquires a number of images from 960–1730 nm in narrow, 3.4-nm-wide bands. The specific bands assigned to each channel are chosen so that their combination in the resulting false-color infrared image allows the greatest legibility of the features in question.

Also many of Caillebotte's vectors used to plan the architectural setting were visible (reinforced here in blue).



Overlay images were registered using a novel image-based algorithm developed by Damon M. Conover (GW), John K. Delaney (GW, NGA), and Murray H. Loew (GW) of the George Washington University's School of Engineering and Applied Science and the National Gallery of Art, Washington, D.C.

For more information, see See Damon M. Conover, John K. Delaney, Paola Ricciardi, and Murray H. Loew, "Towards Automatic Registration of Technical Images of Works of Art," in *Computer Vision and Image Analysis of Art II*, ed. David G. Stork, James Coddington, and Anna Bentkowska-Kafel, Proc. SPIE 7869 (SPIE/IS&T, 2011); doi:10.1117/12.872634.

We then imaged the painting with the IR cameras of Santa Barbara IRC912-SWIR InSb infrared camera with K filter (2.1–2.4 μm). Over 1100 individual tiles were captured using this camera.

At right, the resulting IR image: Infrared image (IRcameras of Santa Barbara, 2.0–2.4 μm)

Image captured by John K. Delaney and Kathryn A. Dooley, the National Gallery of Art, Washington, D.C.

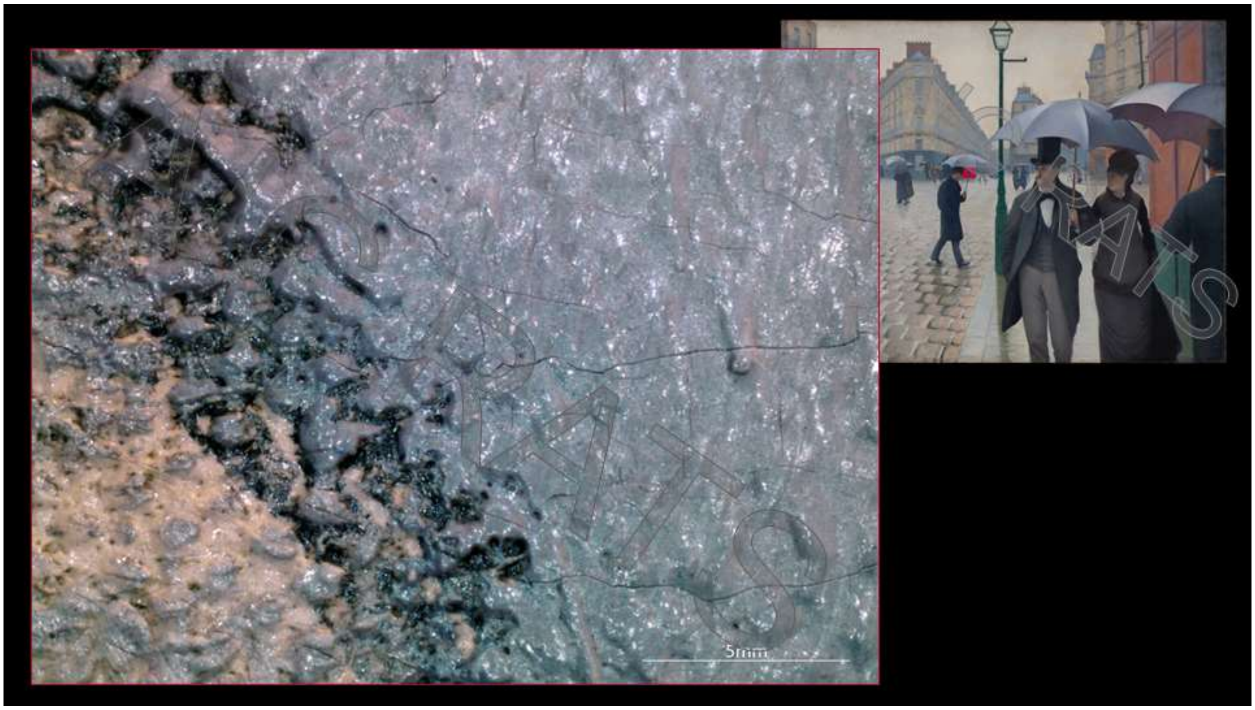
We were processing the images and felt that at this point, we had plenty of information to publish. Wanting the online publication to come out in conjunction with the exhibition and exhibition catalogue meant a very compressed writing schedule. An online scholarly catalogue of Caillebotte's works at the Art Institute would contain just 2 paintings. With so many major discoveries already, we thought our investigative work was done and took the risk.

At right, the second Caillebotte in the Art Institute collection, *Calf's Head and Ox Tongue*, c. 1882, Oil on canvas; 73 × 54 cm (28 1/2 × 21 1/4 in.)

Technical images processed (clockwise from UL): x-ray, reflected- and transmitted infrared images with the modified CCD camera (1.0–1.1 μm); UV; the IRcameras of Santa Barbara K filter IRR, and the hyperspectral false-color IR

Image credits: X-ray scans were digitally composited by Robert G. Erdmann, Rijksmuseum, University of Amsterdam, and Radboud University; modified CCD camera reflected and transmitted infrared, high-resolution normal light and ultraviolet-induced visible fluorescence images by Christopher Gallagher, Art Institute of Chicago; IRcameras of Santa Barbara and hyperspectral false color infrared captured by John K. Delaney and Kathryn A. Dooley, the National Gallery of Art, Washington, D.C.; Hyperspectral image cubes registered by Damon Conover, Kathryn A. Dooley and John K. Delaney; all other images registered by Kelly Keegan

The compositional changes and underdrawing visible in the various images have been annotated in various colors to illustrate the amount and variety of changes Caillebotte made to the painting. The figures appear almost fussed-over: every hat brim, glove and garment fold was adjusted multiple times during the painting process.



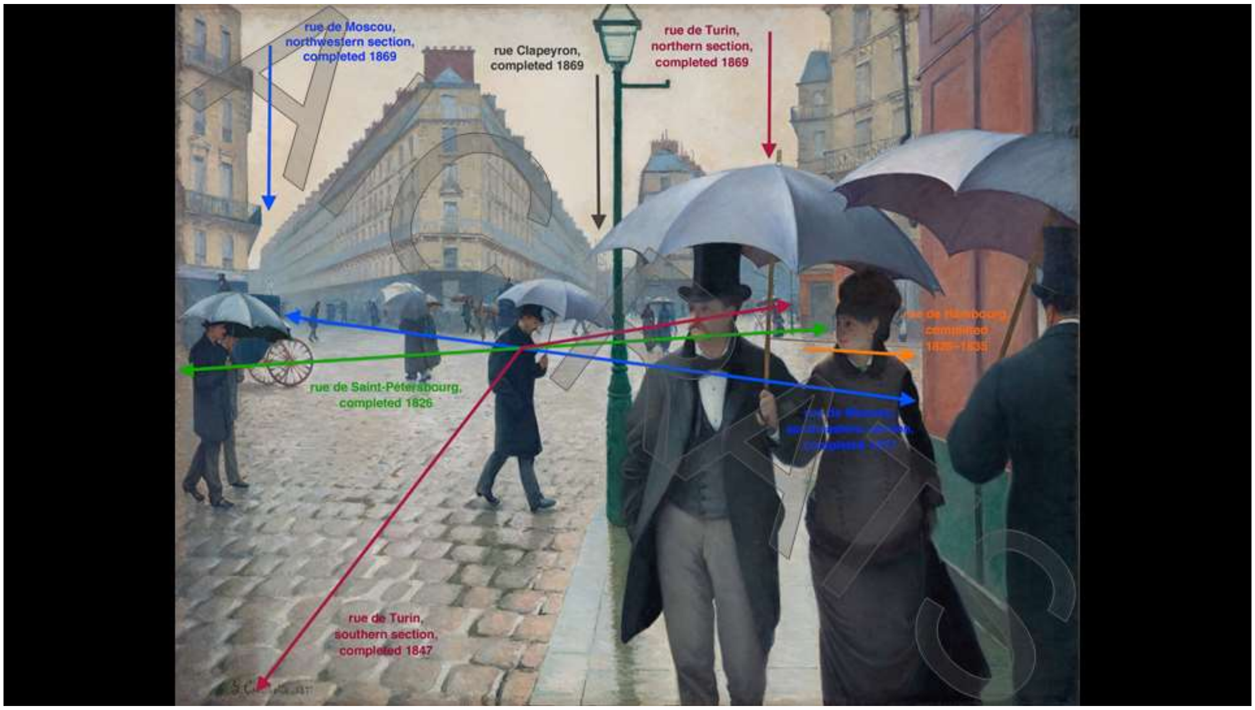
In addition to the underdrawing revealed in the IR images, much was also visible with the microscope. Here is charcoal…

Image: photomicrograph of the area beneath the umbrella at center.

Caillebotte is known to have executed underdrawings in stages beginning with a rough charcoal sketch. Charcoal was identified by SEM/EDX and visual examination of pigment morphology in cross sections. See Federica Pozzi and Inge Fiedler, "Caill_ParisStreet_1964_336_Analytical_Report," Dec. 2, 2014, on file in the Conservation Department, Art Institute of Chicago. See also Katja Lewerentz, "Gustave Caillebottes Maltechnik und die Praxis der Feilichmalerei," *Zeitschrift für Kunsttechnologie und Konservierung* 22, 2 (2008), p. 277.

black (at left) and blue painted lines…

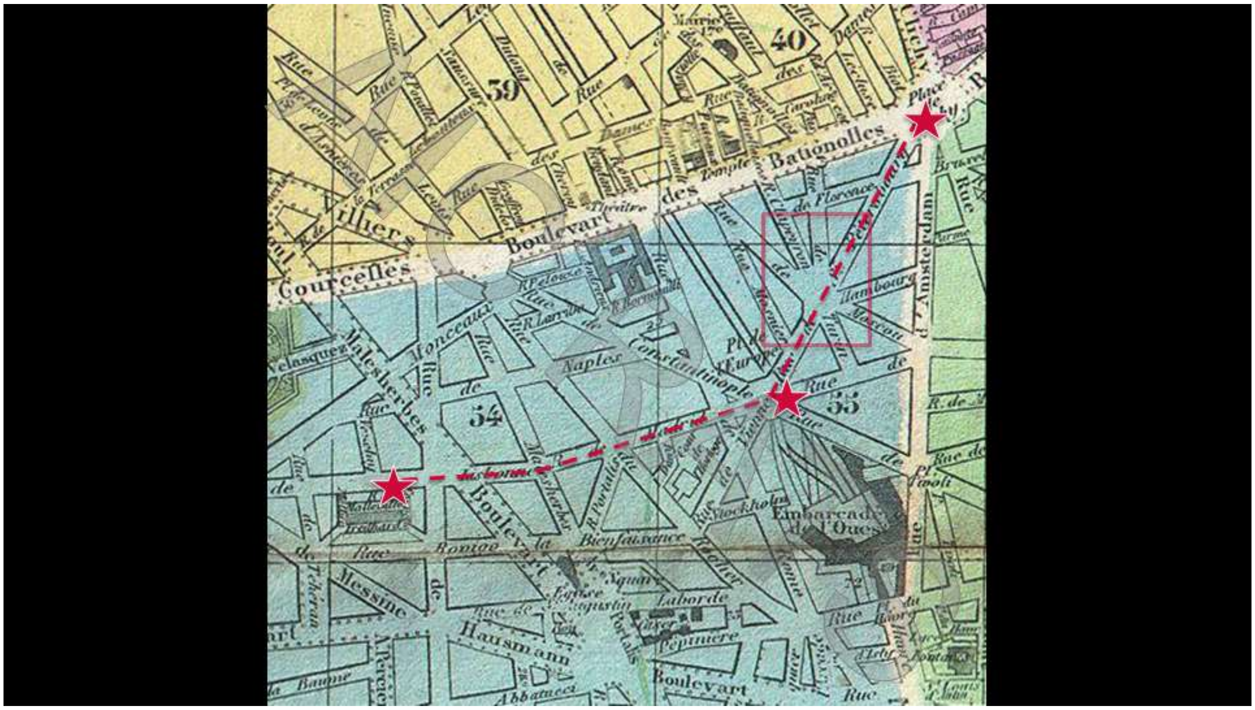
and painted contours in red lake.



We had some understanding of Caillebotte's basic process, but how did he construct his composition?

The setting: In true Parisian style, the composition features a complicated 8-point intersection where 5 different streets meet.

Annotations by Genevieve Westerby



The intersection was familiar site in Caillebotte's neighborhood: he often passed through it on his way from his apartment (star at left) to the cafés (upper right).

He painted another major composition not far from this intersection: the *Pont de l'Europe* (center star)

The area within the rectangle represents the intersection in *Rainy Day*: 5 streets meet – Rue de Moscou and Rue de St Petersbourg intersect and continue, Rue de Clapeyron and Rue de Hambourg begin (or end) here, and the Rue de Turin comes to this intersection and jogs to the right before continuing

Image: Map of Paris, 1878 (detail), in Alexandre Aimé Vuillemin, *Nouveau plan de Paris divisé en vingt arrondissements* (1878). Bibliothèque nationale de France, département Cartes et plans, GE C-7157.

Taking Caillebotte's path along Rue de St Petersbourg, one is faced with a rather disarming triple perspective.

This became a common sight in Hausmann's new Paris.

Also notice the setting slopes up, away from us, and to right.

Image above shows the intersection in its current configuration, mimicking Caillebotte's path (photo 2014)

In his composition, Caillebotte tempers that view slightly, moving off intersection so only one building is clearly visible on both sides.

The image at right is the site today: many of the buildings are extant and largely unchanged, aside from the added glass porch at the right.

The accuracy of drawing and painting to the original site has led many scholars to suggest Caillebotte may have employed an optical device to capture his setting.

Since many of Caillebotte's drawings are similar in size to photogtaphic plates, Peter Galassi suggested in 1976 that Caillebotte may have traced his drawings. See Galassi, "Caillebotte's Method," in J. Kirk T. Varnedoe and Thomas P. Lee, *Gustave Caillebotte: A Retrospective Exhibition*, with contributions by J. Kirk T. Varnedoe, Marie Berhaut, Peter Galassi, and Hilarie Faberman, exh. cat. (Museum of Fine Arts, Houston, 1976), p. 199. More recently, the painting and drawing's accuracy has been confirmed by overlaying them with a digital 3D rendering of the site as it was in Caillebotte's time: Claude P. J. Ghez and Orselie Bernier, "Gustave Caillebotte's 'Jour de Paris, temps de pluie': From Cityscape to Stage Set" (unpublished manuscript, 2014).

(above) the painting overlaid with the site in 2014

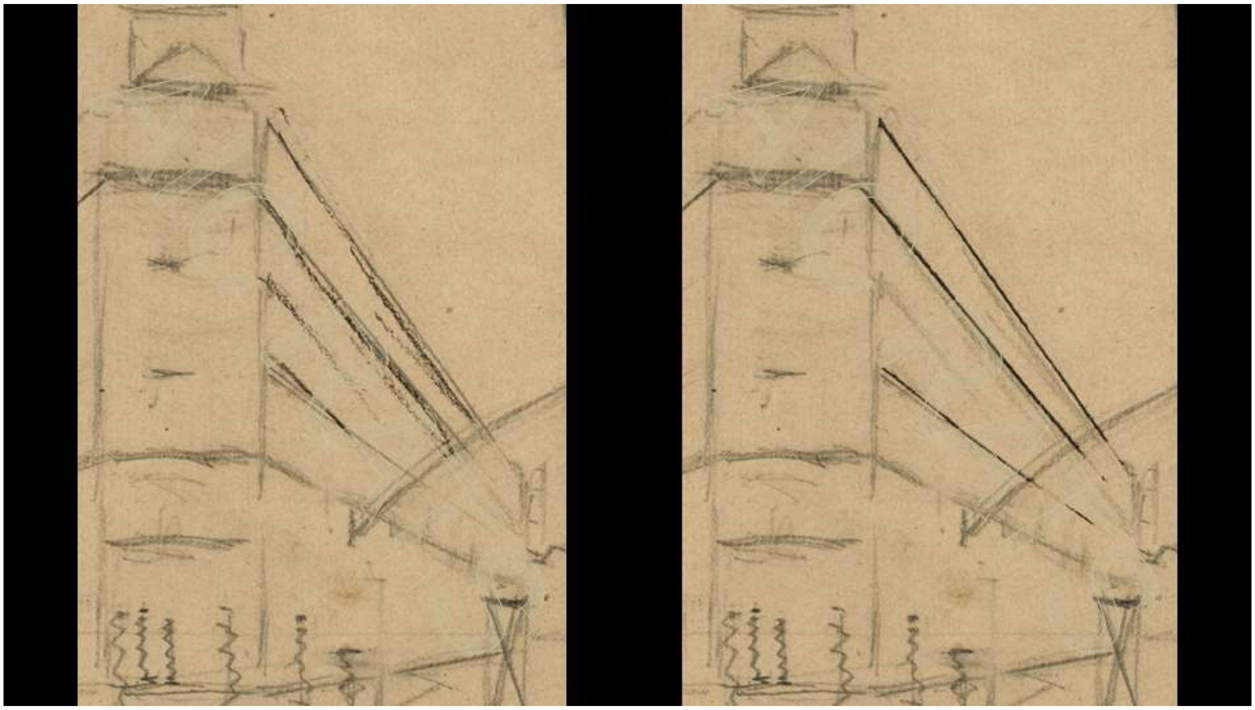
The painting was noted for its broad angle of view (or side to side panorama), and for a number of "wide-angle" effects including the relative scale of the foreground elements to those in the background, and the apparent splaying of the foreground cobble stones.

However, comparing the painting to the drawing, one thing is clear: Caillebotte added approximately 17% of the foreground to the area covered in the drawing to accommodate his walking figures. The splaying of the foreground was not part of the original scene.

Image: drawing enlarged and overlaid with the painting

So it's really the relationship of the drawing alone to the site that should be examined

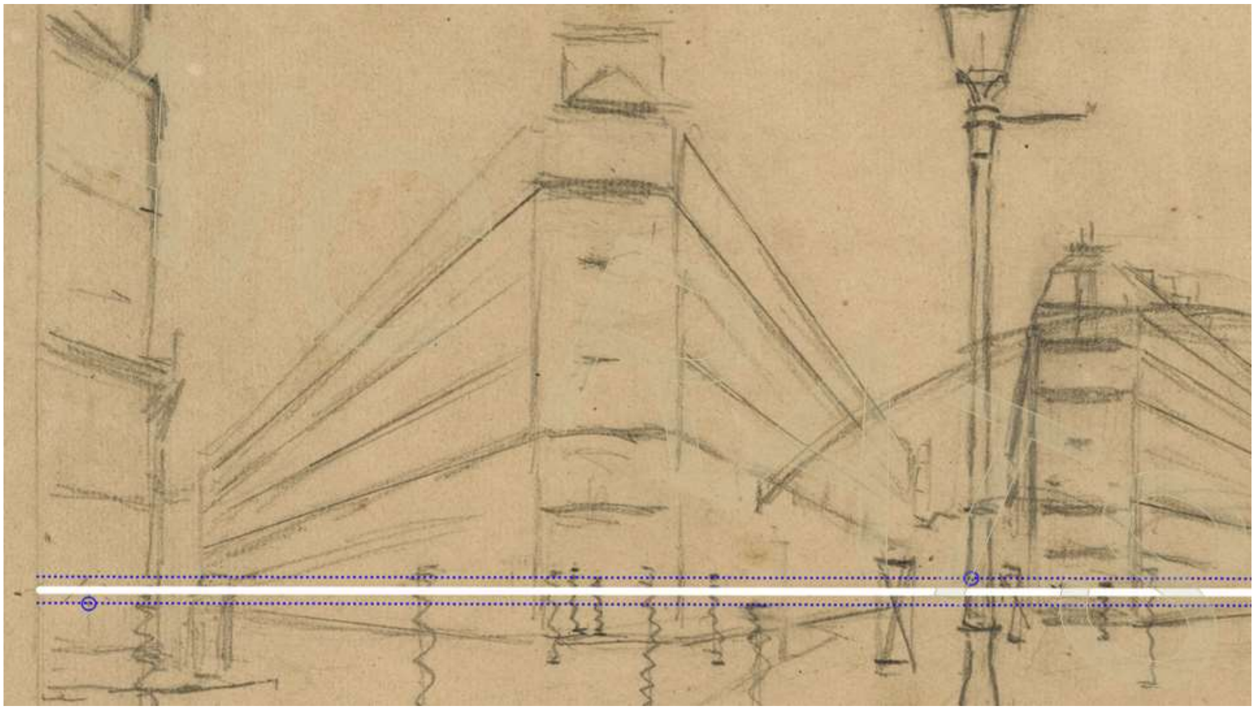
Image: drawing overlaid with the site in 2014



Close examination of the drawing revealed it was really two drawings superimposed on the same sheet

The first sketch, presumably done on site, features sketchy lines (using building 2 as an example, these lines are reinforced on the left)

The second phase = back in studio, ruled lines, and the perspective is regularized and clarified



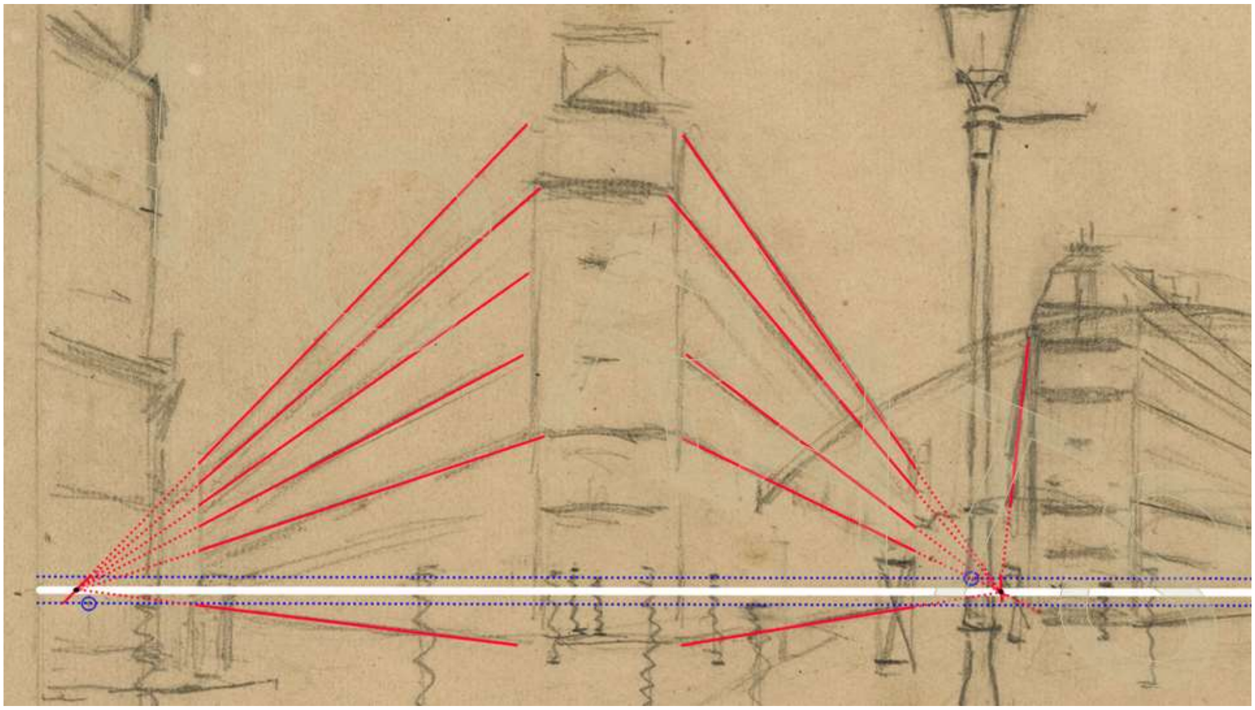
Caillebotte needed to clarify his drawing to enable easier transfer, and did so with the aid of a ruler or straight edge.

This ruling step involved adjusting the perspective slightly, using building 2 as an example (since both sides are clearly visible).

Circled in blue are very small tick marks on the drawing: these are apparent the vanishing points for each side of this building. (As a reminder, a vanishing point = the point on the horizon where parallel lines meet)

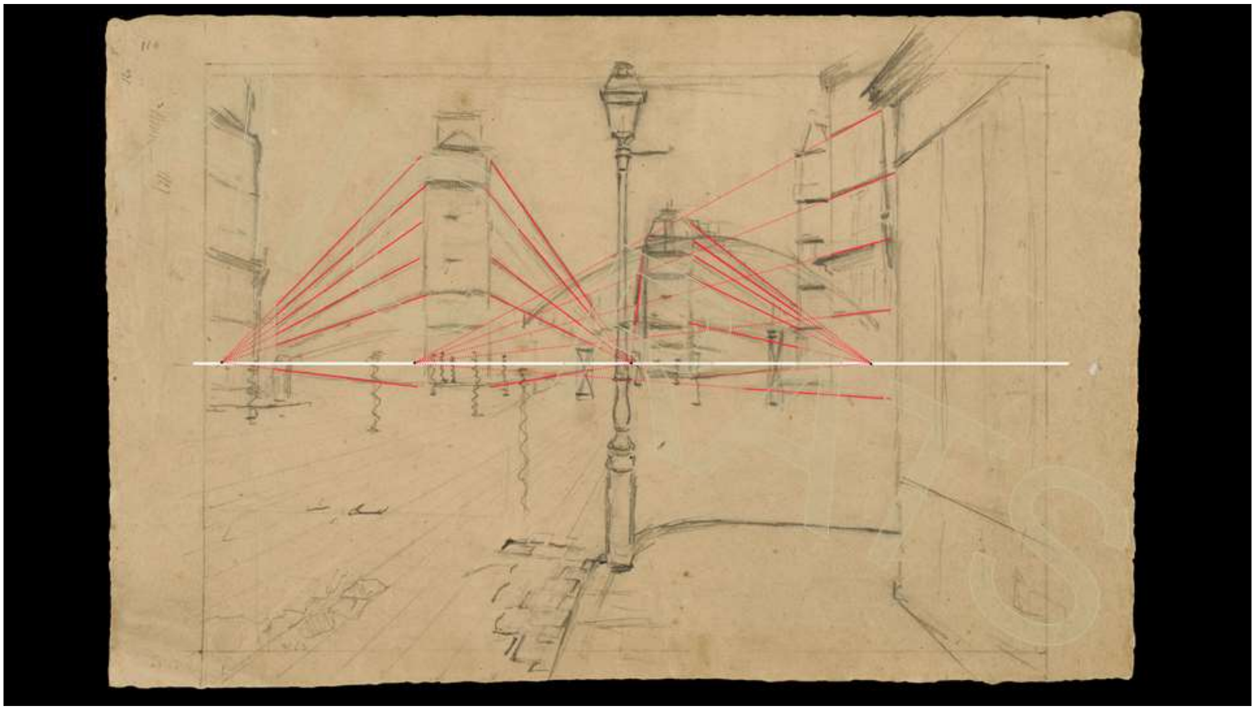
The artist split the difference between the horizons indicated by these tick marks to create a new horizon (in white).

This effectively flattens the left to right upward slope of the original site.



Caillebotte makes new vanishing points on the new horizon, and moves them both slightly outward.

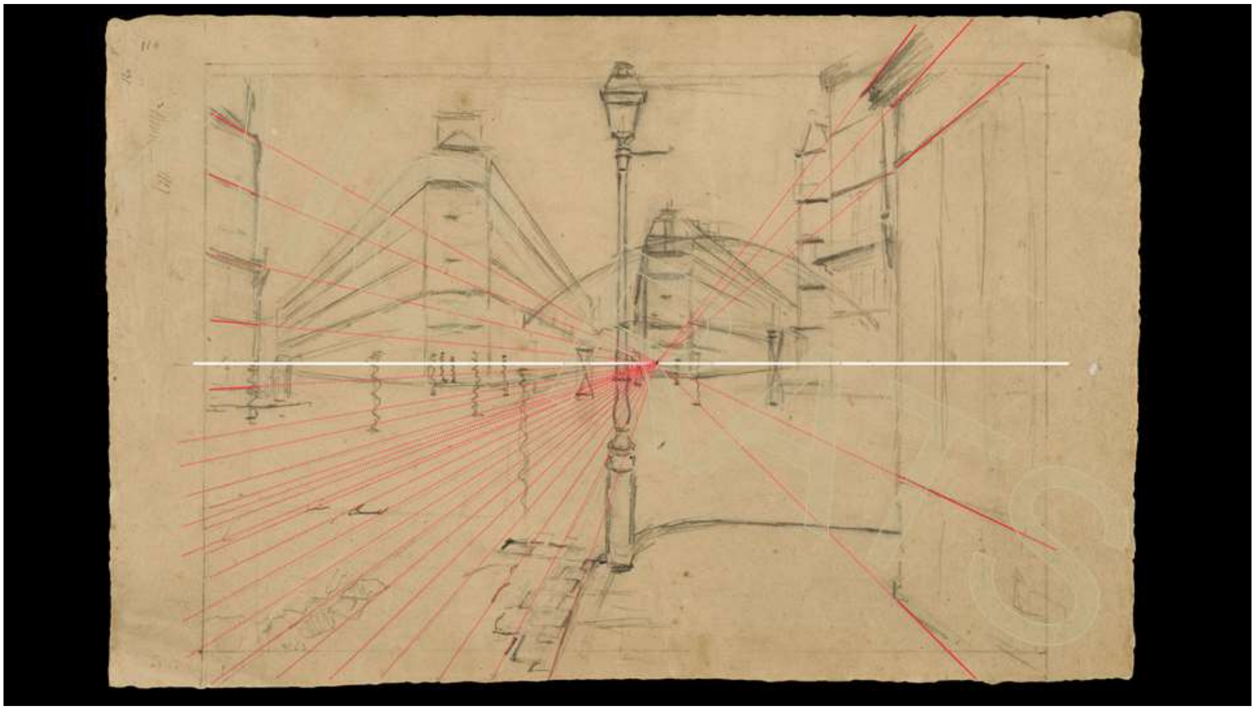
Red lines = newly angled sides



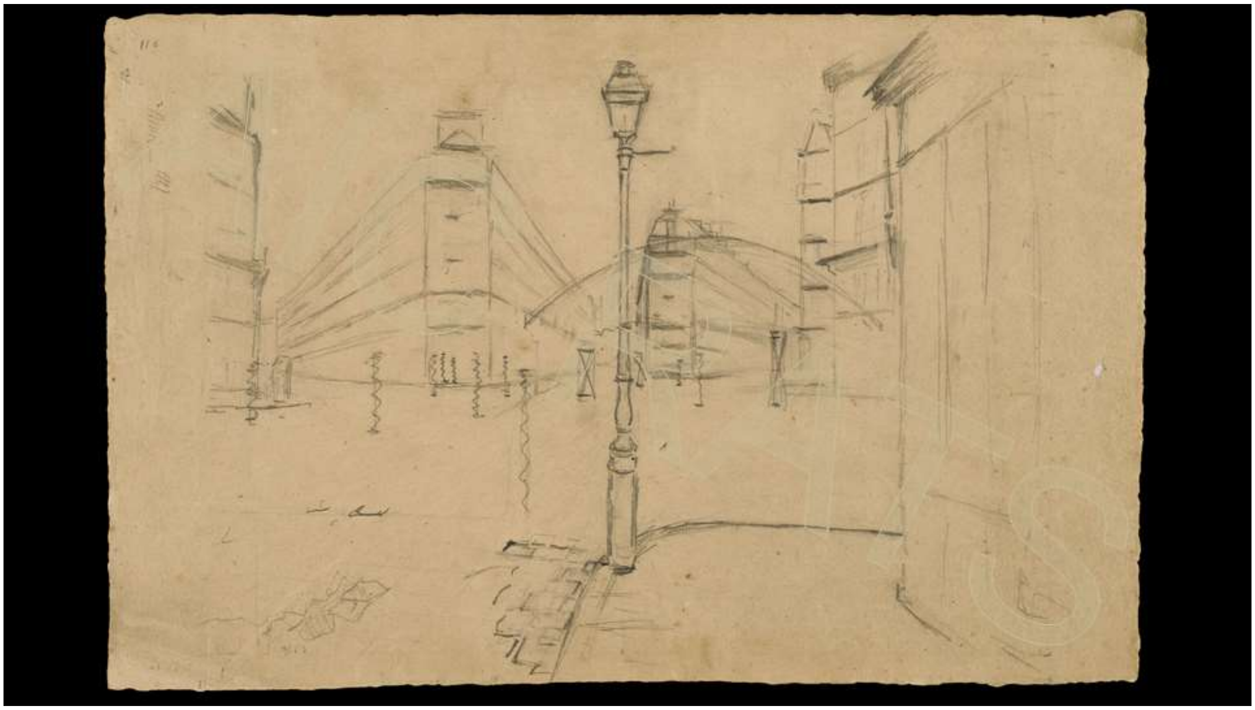
This ruling step widens almost all the buildings slightly.

Moving the vanishing points by few mms on drawing effectively raises the vantage point in it and the final painting to eye level.

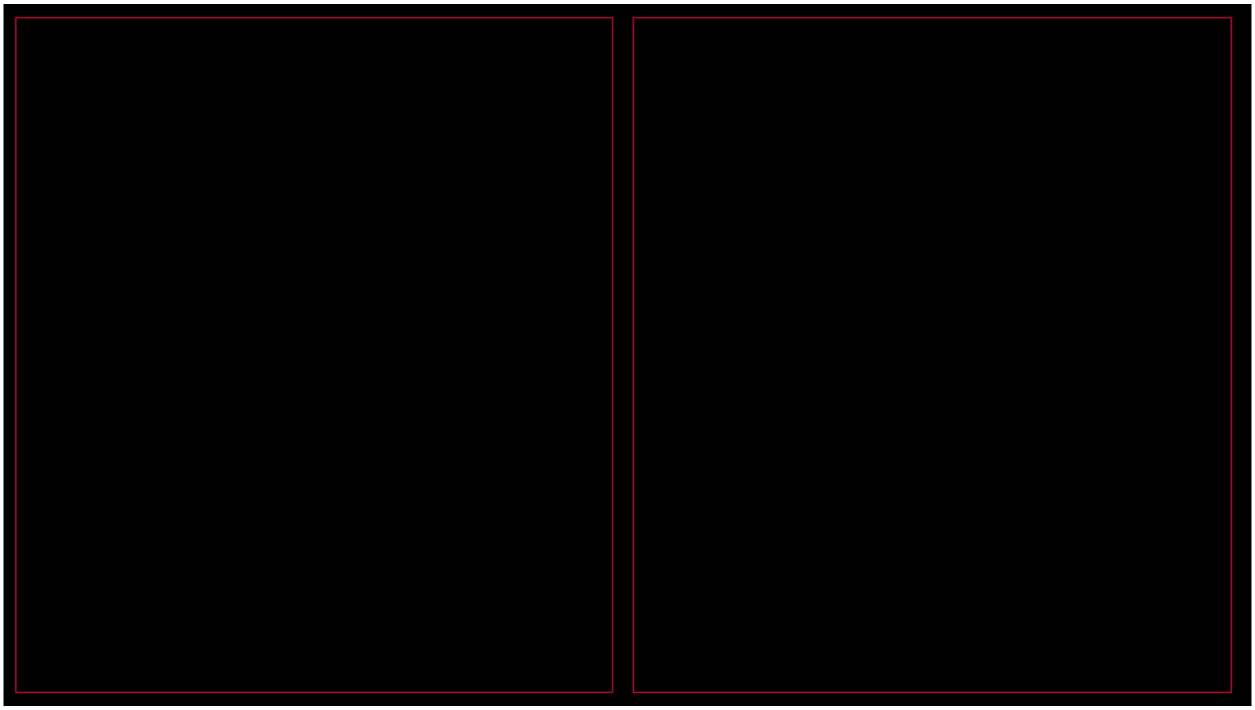
Put another way, the steeper angles of on-site sketch suggest a vantage lower than eye level.



As part of this step, Caillebotte also simplifies the intersection, combining the two foreground avenues into single wide space. The single vanishing point is the viewer's vanishing point. This small change creates a unified, enveloping environment in the foreground, aiding the idea that the viewer could walk right into the painting.



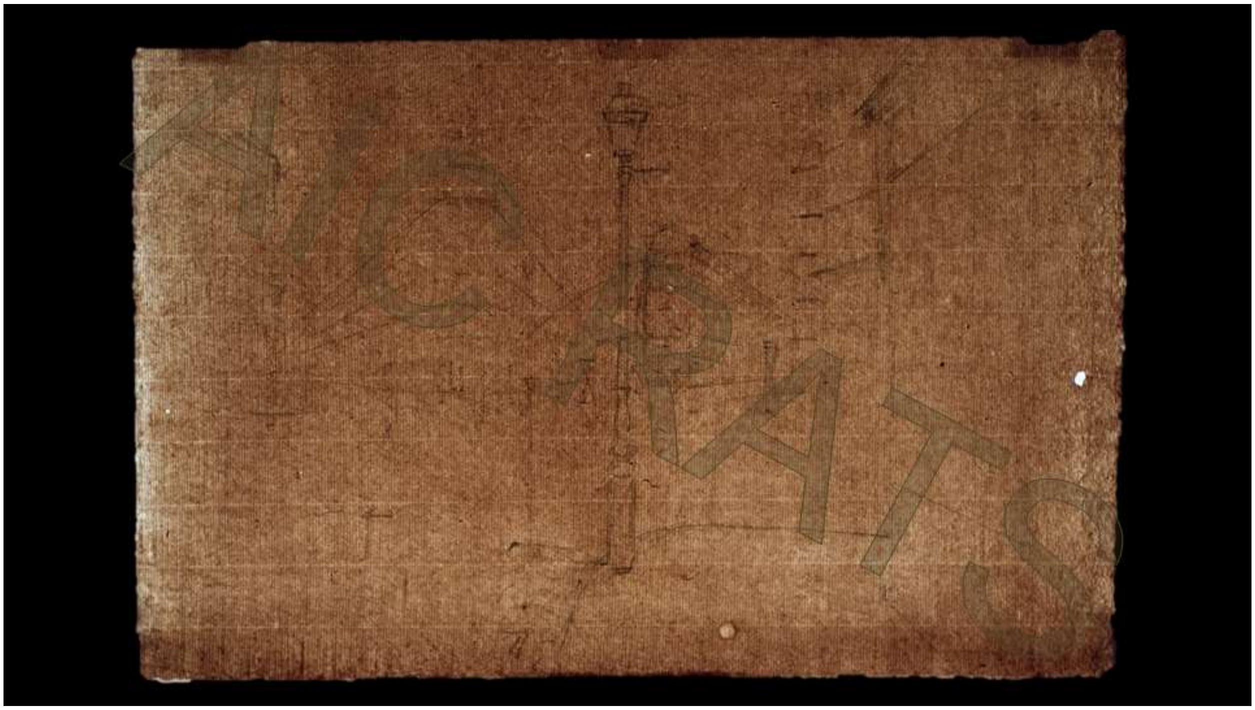
To aid in determining if an optical device was used to make the drawing (and if so, which one), we digitally reduced ruling step to isolate on-site sketch.



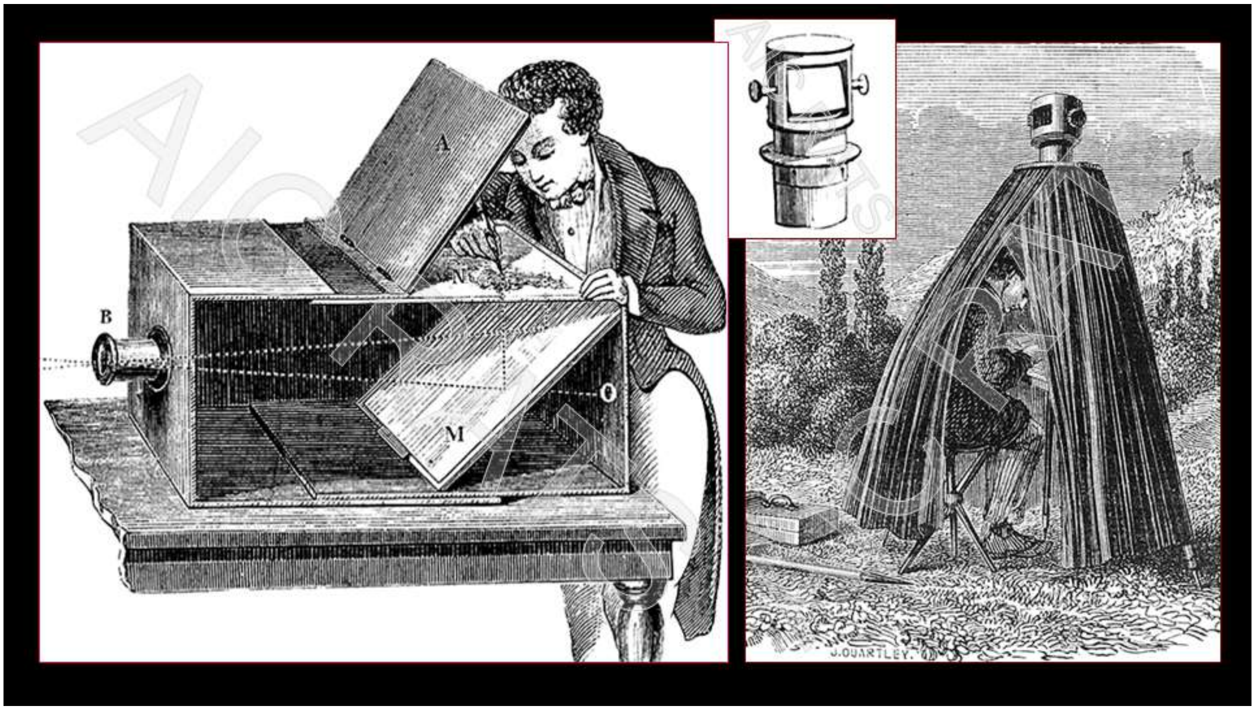
(Images: 19th century photographic cameras [*Images removed due to copyright restrictions*])

Among the most common optical devices at his disposal was the photographic camera: Caillebotte could trace a photograph or the image on the ground glass.

However, Caillebotte would need specific lens to get broad angle of view.



Also, the transmitted light image of the paper (by Toni Owen) showed it was too thick for any kind of tracing.



There was also the camera obscura (the box model at left).

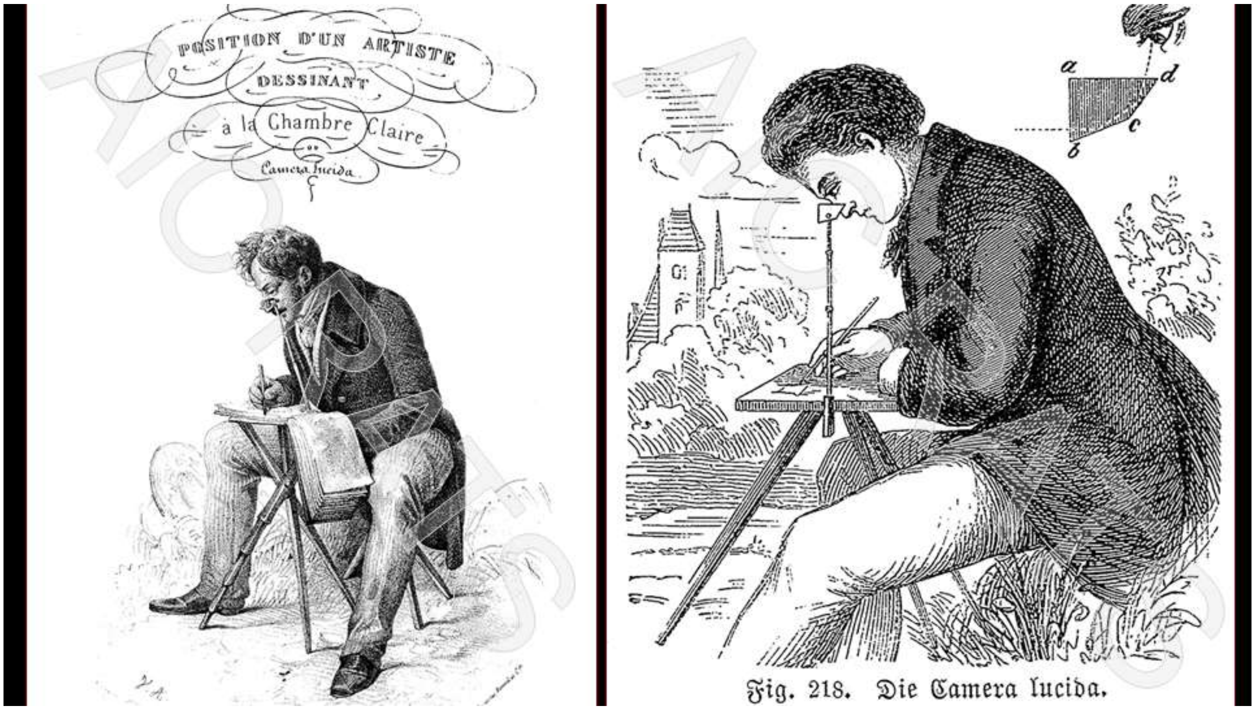
In the 19th century, there was also a tent camera obscura (at right), where the artist sat within a cone of fabric and traced the image coming from above.

The tent camera obscura employed a prism instead of lens, meaning there would be no lens distortions, and no depth of field/focus issues.

The revolving turret (top center) on the tent camera obscura would accommodate the broad angle of view.

Remember the on-site sketch: the steeper angled buildings suggested a vantage below eye-level: the vantage of a tent camera obscura appears to be too high

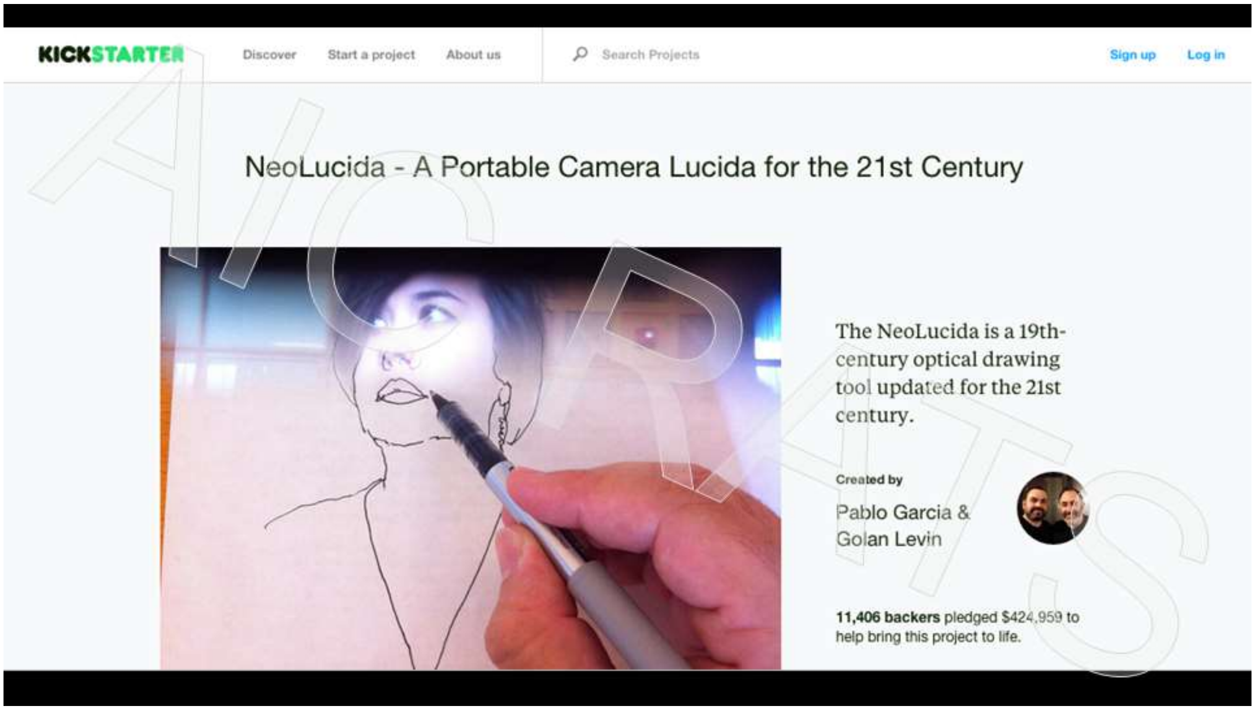
Images: box camera obscura (left) and tent camera obscura (right) from *Elementary treatise on physics, experimental and applied, for the use of colleges and schools*. Translated and edited from Ganot's Éléments de physique (with the author's sanction) by E. Atkinson, 1875 (full text: https://catalog.hathitrust.org/Record/100327460)



Scholars of Caillebotte often mentioned the previous optical devices in addition to something called a camera lucida

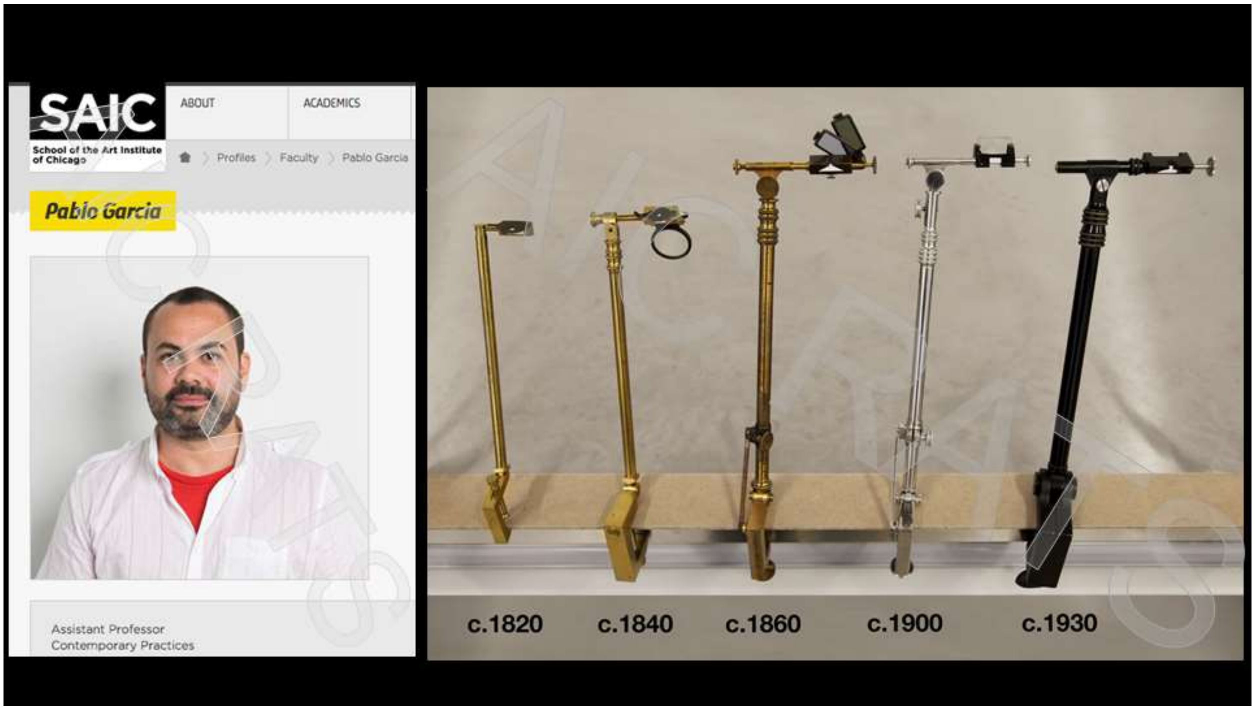
What is a camera lucida?

Images: (left) The cover of Charles Chevalier, *Conseils aux artistes et aux amateurs, sur l'application de la chambre claire à l'art du dessin* (C. Chevalier, 1838) and (right) illustration of a camera lucida *in Das neue Buch der Erfindungen, Gewerbe und Industrien. Rundschau auf allen Gebieten der gewerblichen Arbeit. 2. Bd: Die Kräfte der Natur und ihre Benutzung. Physikalische Technologie (enthält u.a. die Geschichte der Windmühle, Schiffsscharube, Hebel, Flaschenzug, Pendel, Wage, Barometer, Luftballon, Licht, Spiegel, Prisma, Camera obscura, Mikroskop, Fernrohr, Blitzableiter, Telegraph, Kompaß, Töne, Sprachrohr, Thermometer, Dampfmaschine etc.*) (Julius Zollner, 1877)



In researching the camera lucida online, I came across a page for the "NeoLucida"

http://neolucida.com/



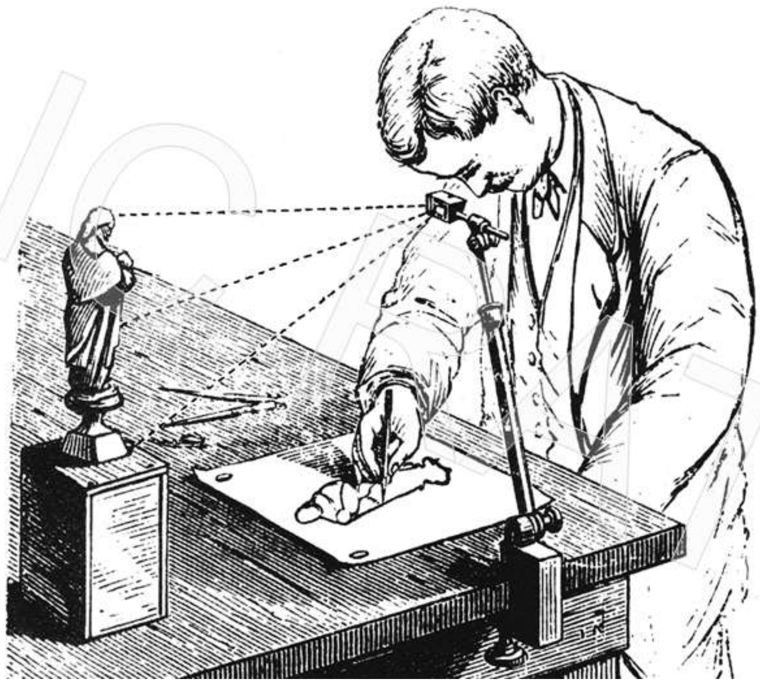
One of the creators was Pablo Garcia (left), who happened to be an Assistant Professor of Contemporary Practices at the School of the Art Institute of Chicago (essentially across the street from the museum).

Pablo had also previously trained as architect.

Inspired by David Hockney's *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters*, he become a self-taught expert in the use of optical devices by artists.

Image at right: his personal collection of camera lucidas

See a variety of optical devices and their history: https://drawingmachines.org/



The term “camera” in camera lucida is a misnomer: the device doesn’t make a picture, and only the user can see the illusion.

It is essentially a prism attached to a rod mounted to drawing table that creates a translucent ghost image of subject ahead, through which the artist can see their paper and pencil.

The device could accommodate a broad angle of view (70–80º with a tilt of the head), and employed a prism (meaning no lens distortion and clear focus from the foreground to the background).

They were readily available as they were sold at the opticien, a purveyor of lenses including photographic cameras, camera obscuras, and binoculars.

Image: c. 1850 illustration of a camera lucida (artist unknown)

We invited Pablo to the Conservation studio at the museum to give us a demonstration.

He brought his mid- to late-19th century camera lucidas, we brought the drawing.

Images: (left) Toni Owen trying the camera lucida with Research Associate Genevieve Westerby; (right) Pablo and Gloria Groom, Chair and David and Mary Winton Green Curator for European Paintings and Sculpture, and our curatorial counterpart for this research

The demo was so successful, Gloria sent Pablo to Paris to try the device on site.

[video]

Can be seen here: https://publications.artic.edu/caillebotte/reader/paintingsanddrawings/section/492/492_anchor

Pablo took a to-scale facsimile of Caillebotte's drawing and determined that not only did Caillebotte very likely use a camera lucida for his sketch, but he also determined the exact vantage point of the drawing.

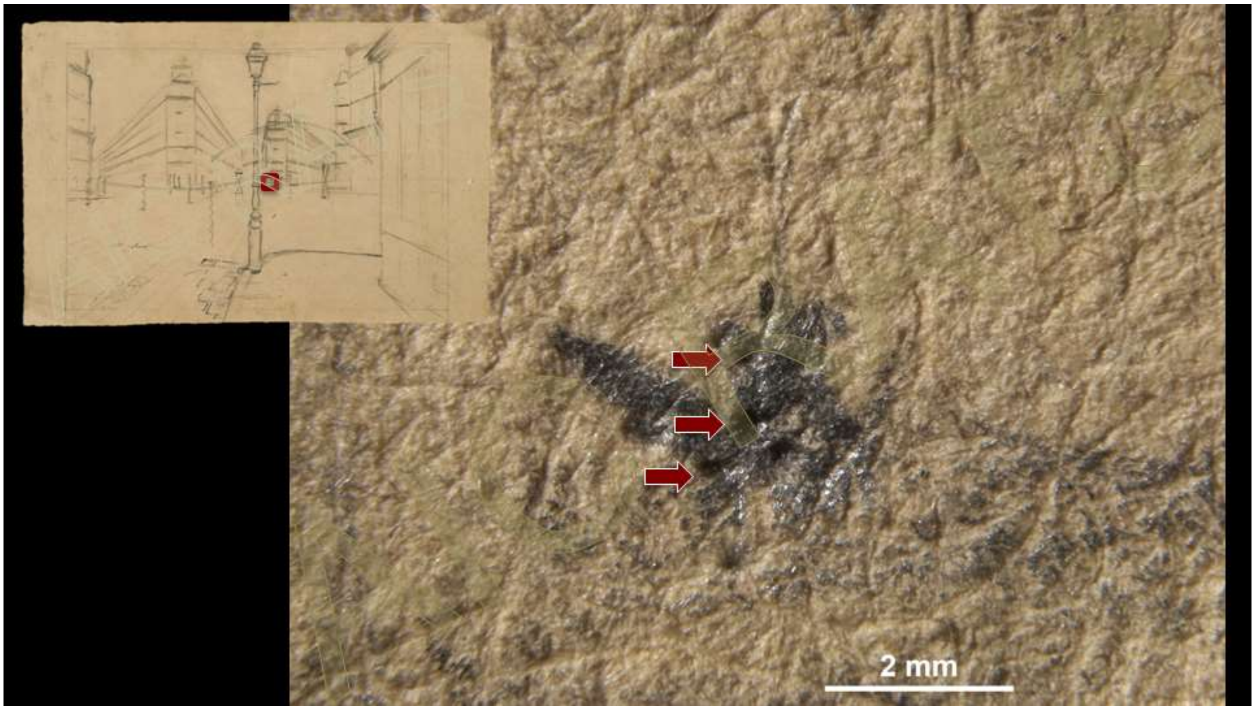
Here the drawing is enlarged and overlaid with the painting via Photoshop. Having worked with the digital images like this, and seeing the closeness with which the drawing matched the architectural features in the painting (and the original placement of the building at the far right) led to the suspicion that the drawing may have been directly enlarged to create the basic underdrawing for the painting.

The drawing and painting side by side in relative scale to one another.

How did this transfer occur? There is no evidence of a grid on either the drawing or painting.

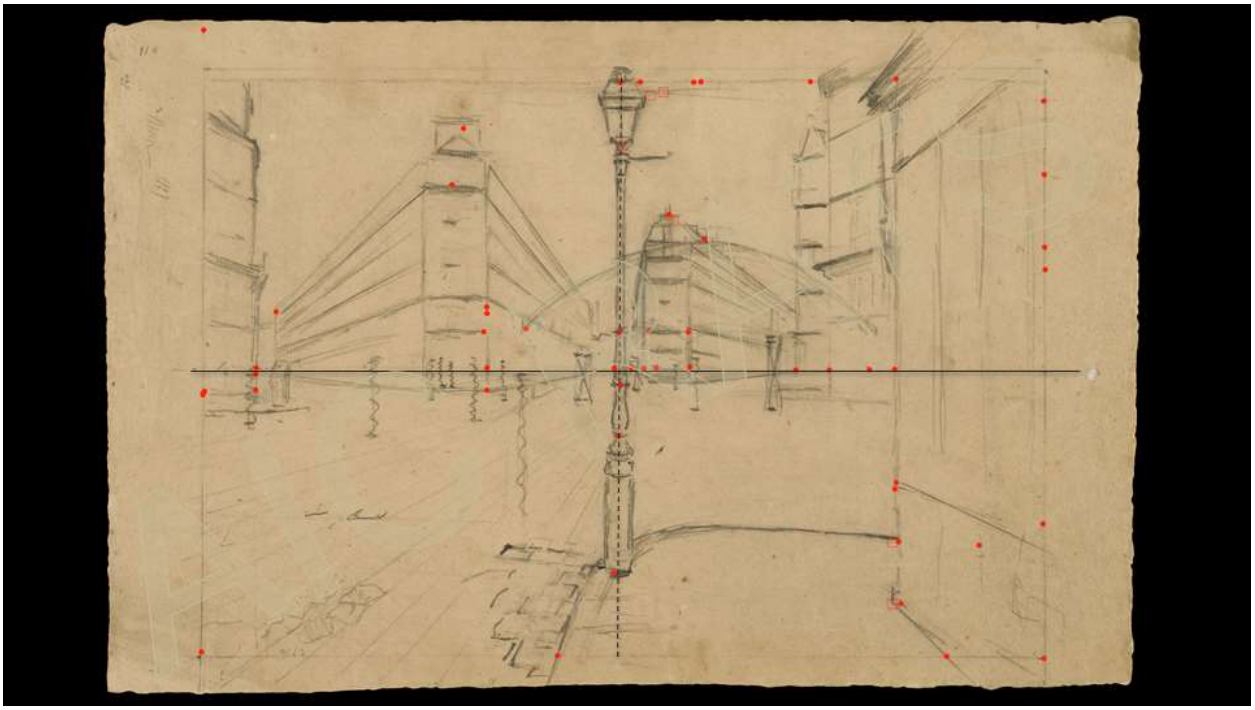
Measuring some of the distances on the drawing compared to the painting, there is a roughly 1:7 factor of enlargement.

Many thanks to Grainger Executive Director of Conservation and Senior Paintings Conservator Frank Zuccari for this observation. The ratio is given as an approximation due to the many changes in the painting from the drawing and the inherent difficulty in comparing single graphite lines to brushstrokes of varying widths. Small discrepancies between the re-created enlargement and the visible underdrawing for *Paris Street; Rainy Day* may also be due to rounding or slight adjustments by the artist during the transfer process.



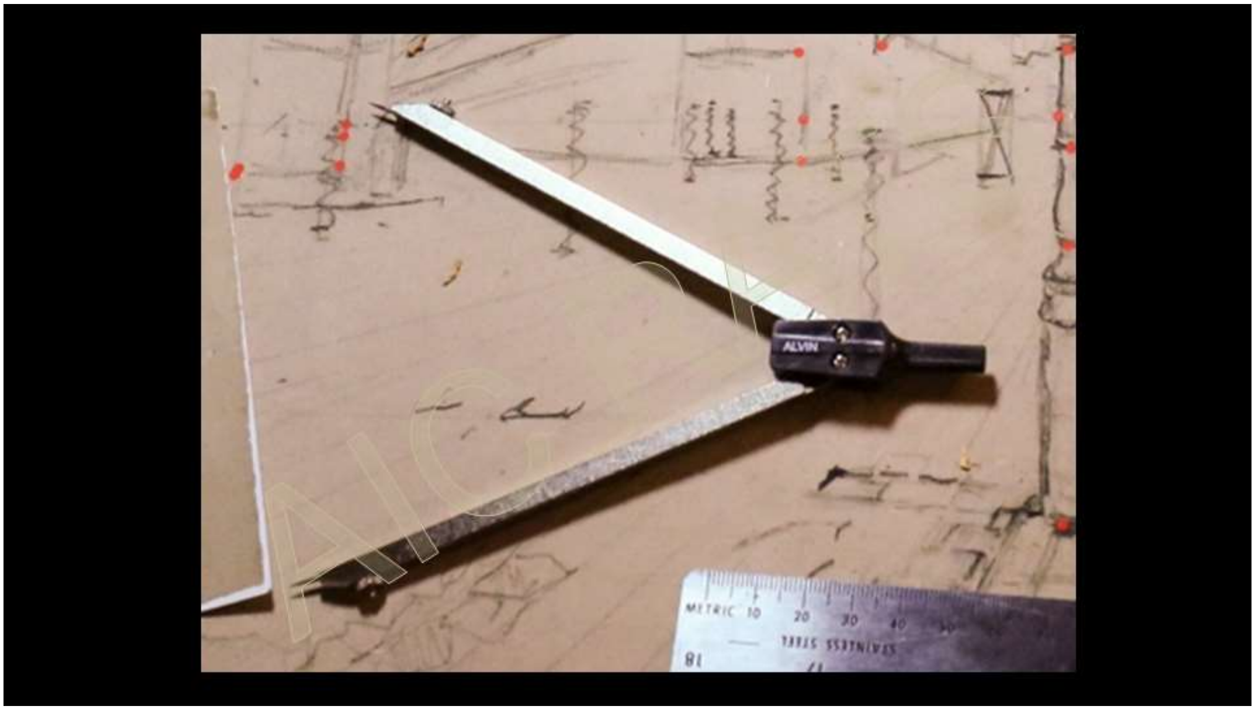
The drawing provided a clue:

Toni Owen, during her examination of the drawing with a high-powered microscope, noted indentations on the vanishing points.



She found them in other strategic places throughout the work (red dots): many were concentrated on horizon and central vertical axis.

These marks cannot be seen without a microscope, so they not purposeful marks, but may be marks left by a tool.

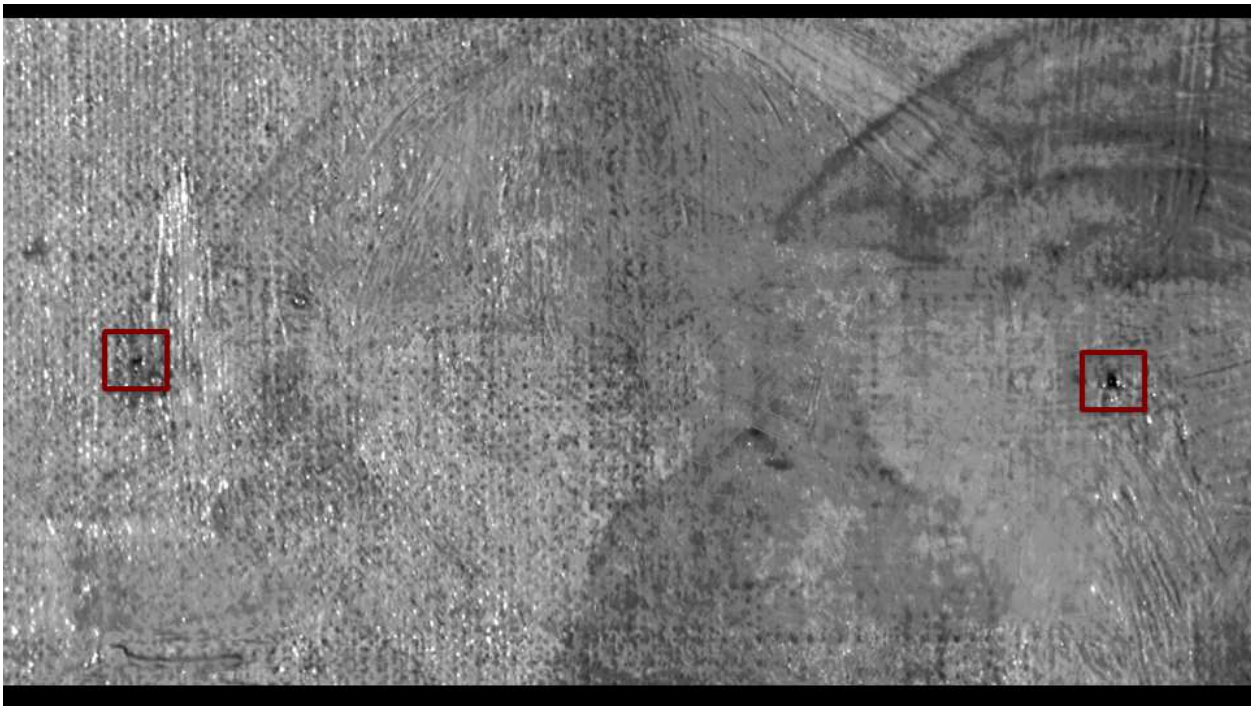


The marks suggested the use of compass or proportional calipers, which can measure discreet distances. These distances could be multiplied by 7 and transferred to larger canvas.

Looking closely at the two right-of-center vanishing points in the K filter IRR image of the painting…

Image: Infrared image (IR cameras of Santa Barbara, 2.0–2.4 μm)

Image captured by John K. Delaney and Kathryn A. Dooley, the National Gallery of Art, Washington, D.C.

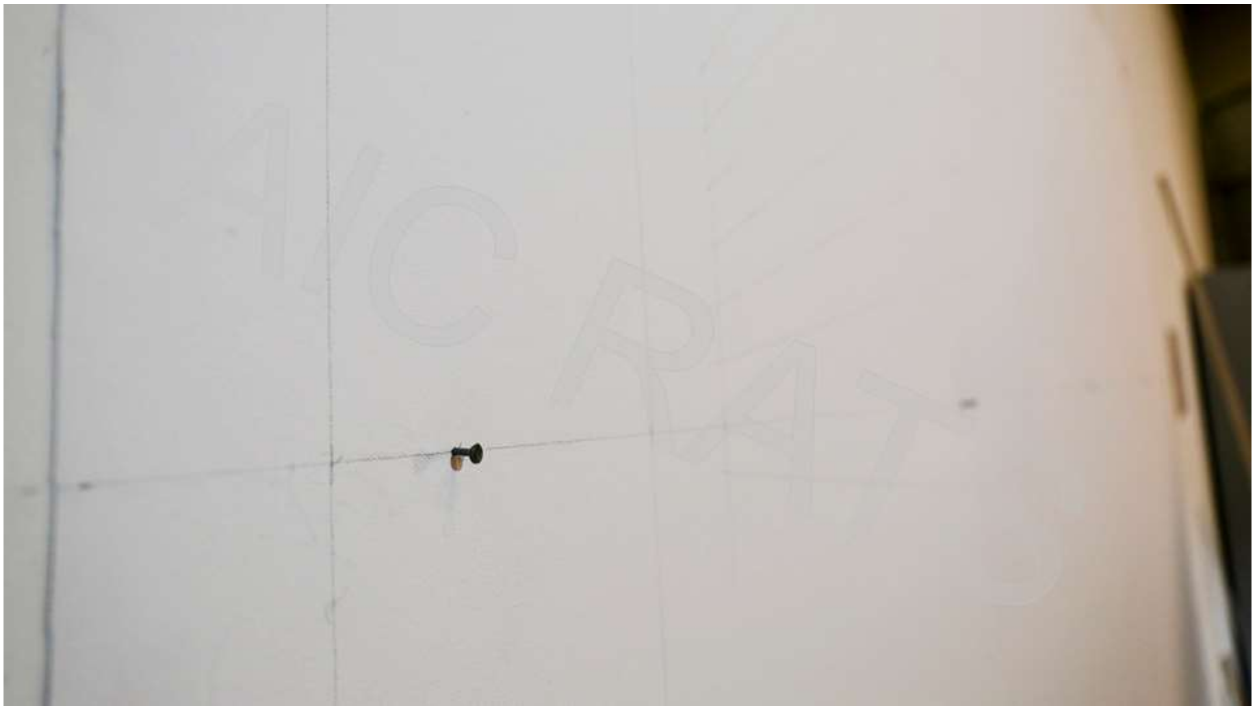


the vanishing points turned out not to be points, but holes.

Pablo suggested that, given the scale of the canvas, and if it was tacked to studio wall, tacks or nails in the vanishing points would aid in bracing the straight edge.

Pablo came back to the Art Institute to attempt the enlargement from the drawing to a pre-primed canvas tacked to the wall, using Caillebotte's method and a facsimile of the drawing (hanging on the wall at R).

The tools of enlargement: distances between the vanishing points along the horizon, and between intersecting lines on the surrounding buildings were marked with the calipers, the distance measured on the ruler, then multiplied by seven and transferred to the large canvas.



Mimicking what we believe was Caillebotte's method, small nails were driven through the vanishing points.

Those nails braced the straight edge to create linear perspective.

In this example, the distances between stories along the vertical axis were translated from the drawing, and their angle determined by the vanishing point.

The “Enlargement” video can be viewed here:
https://publications.artic.edu/caillebotte/reader/paintingsanddrawings/section/492/492_anchor

The experiment worked! We had determined Caillebotte's method of enlargement.

Image: Pablo's enlargement overlaid with the painting 1:1, with the drawing at right at relative scale

Many people collaborated on this project

Images: (clockwise from UL) Pablo Garcia and his daughter, with Caillebotte's great-nephew, and curator Gloria Groom in the gallery; John Delaney and Kate Dooley; Frank Zuccari testing the camera lucida; Toni Owen and Genevieve Westerby; Faye Wrubel cleaning the painting; and (center) Toni and Pablo examining the drawing


A team effort: Sincere thanks to the following…
Rest of the Caillebotte team
Toni Owen
Gloria Groom
Genevieve Westerby
Faye Wrubel
Frank Zuccari
Art Institute of Chicago
Francesca Casadio
Inge Fiedler
Bill Foster
Chris Gallagher
Robert Lifson
Federica Pozzi
Tom Riley
Kenneth Sutherland
Kirk Vuillemot
National Gallery
Kate Dooley
Mary Morton
George Washington University
Damon Conover
Murray Loew
Robert G. Erdmann (Rijksmuseum, University of Amsterdam, Radboud University)
Don Johnson (Rice University)
Caroline von Saint-George (Wallraf-Richartz Museum & Fondation Corbaud)
Mellon Foundation
Mary Winton Green Research Fund
ART INSTITVTE CHICAGO
NATIONAL GALLERY OF ART U.S.A.
SAIC

Reproducibility in Quantitative XRF Analysis of Copper Alloys: Problems and Ways Forward

Arlen Heginbotham, V. Armando Solé

This presentation will offer an overview of the challenges facing those seeking to use ED-XRF for quantitative analysis of cultural heritage copper alloys, and will describe a proposed method for maximizing the reproducibility of measurements between laboratories. By maximizing inter-laboratory reproducibility, this method should facilitate collaboration among researchers and allow the rigorous use of shared data and databases. Recently, interlaboratory reproducibility has been shown to be quite poor. The results of a 2010 round robin study will be discussed and possible explanations for the difficulties encountered will be described. The proposed method for improving reproducibility, nicknamed CHARMed PyMca, calls for the use of free, open source, fundamental parameters software called PyMca. PyMca allows for a consistent and transparent application of the fundamental parameters approach independent of the ED-XRF instrumentation used. In order to further improve reproducibility, the proposed method calls for the calibration of standardless PyMca results against a set of high-quality certified reference materials designed specifically for use with heritage copper alloys, the so-called copper CHARM set. Finally, this method calls for the calibration-to-standards to be carried out following a consistent strategy, including error modeling and the incorporation of a validation procedure. The results of a second round robin reproducibility study will be presented which demonstrate the efficacy of the method.

Towards Quantitative Reflectance Transformation Imaging

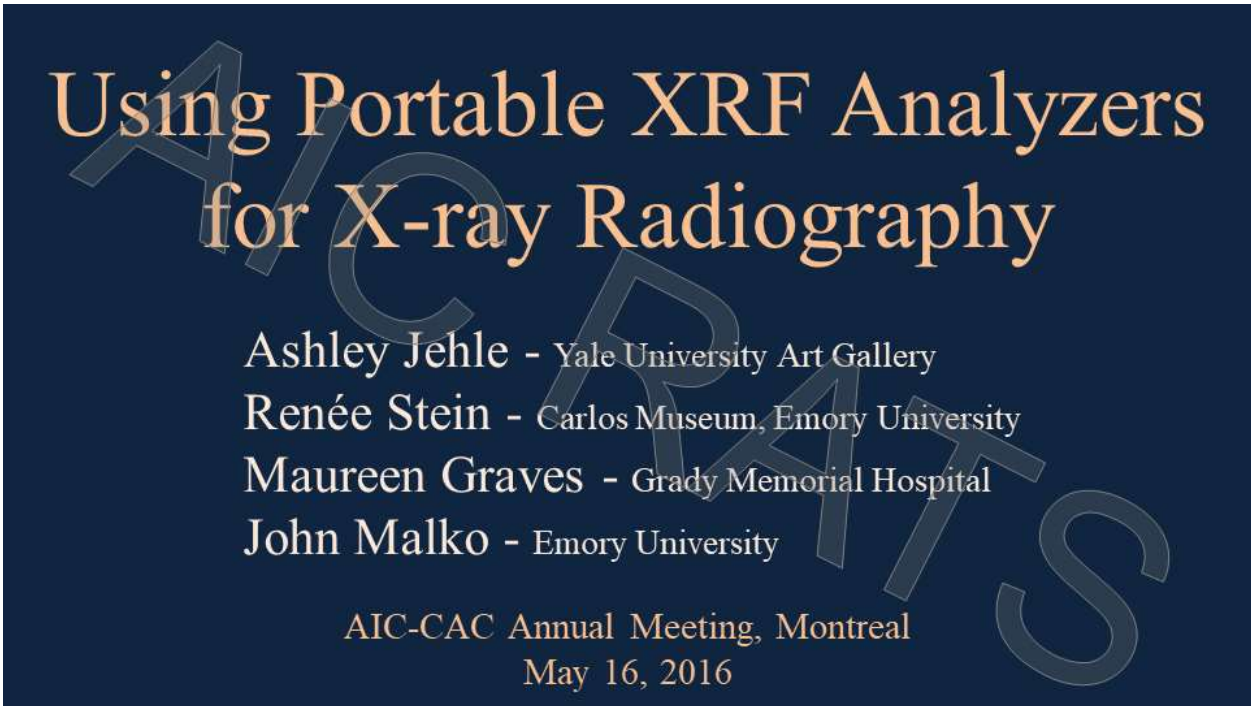
Marc Sebastian Walton, Greg Bearman, Oliver Cossairt, Xiang Huang

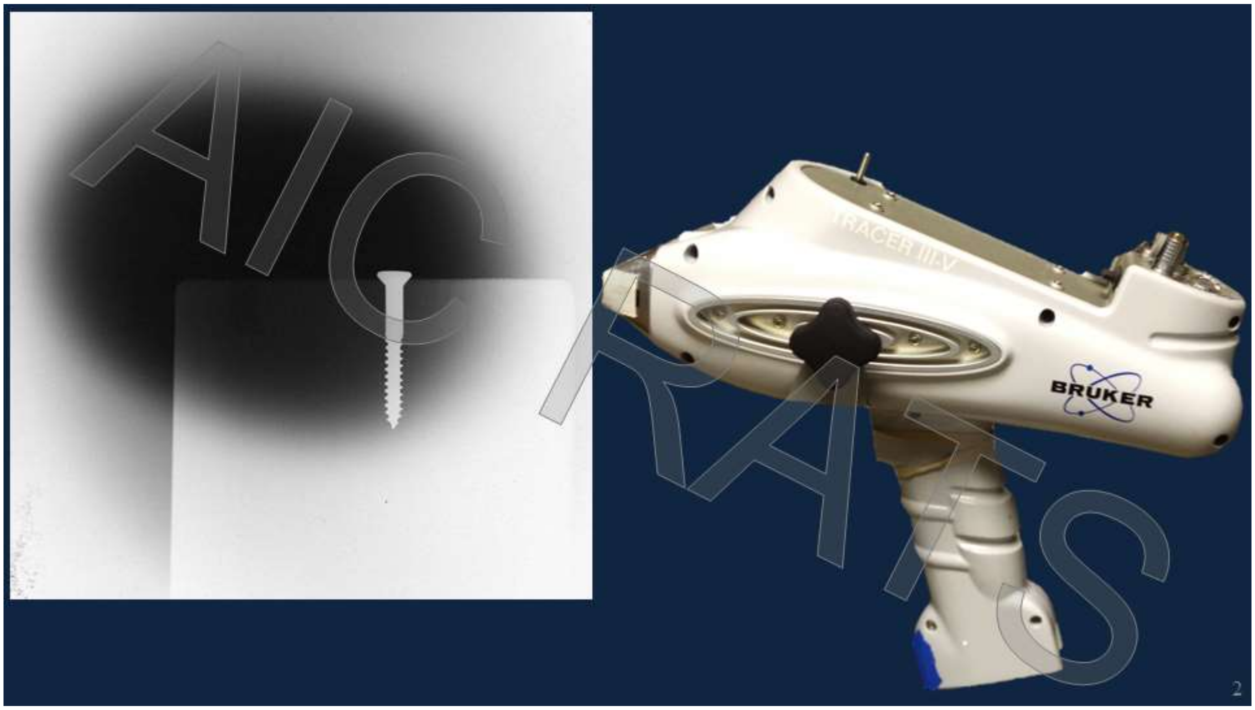
In this talk we will show how reflectance transformation imaging (RTI) can be used as a quantitative technique capable of visualizing and measuring the surface shape of works of art. RTI utilizes multiple images captured from a fixed camera position but lit from various different directions to create an interactive composite image that reveals textural characteristics of materials. While current RTI methods offer conservators a powerful exploratory tool, the many systematic approximations inherent to the technique limit its use to qualitative assessments of appearance. As one step towards quantitative surface estimations, we address a fundamental limitation of the RTI model, that the whole object is lit from the same illumination angle with the same illumination intensity across the entire field of view. This requirement is rarely met in real-life experimental conditions because the light would need to be placed infinitely far away from the object. The mismatch between the lighting model and real experimental conditions has been documented to produce erroneous surface normal estimations, a "potato-chip" shape estimation error when the surface normals are integrated, and non-uniform illumination effects in relighting that we call the 'spot-light' effect. Using our new algorithm and capture methods, we show how to correct for these errors and advance RTI making it a practical and repeatable method to digitally capture the surface texture of a work of art. As a practical example to demonstrate the effectiveness of this approach, we will show high-quality 3D reconstructions of RTI data captured from the Art Institute of Chicago's collection of the graphic works of Paul Gauguin.

Using Portable XRF Analyzers for X-ray Radiography

Ashley Jehle, John A. Malko, Maureen R. Graves, Renee A. Stein

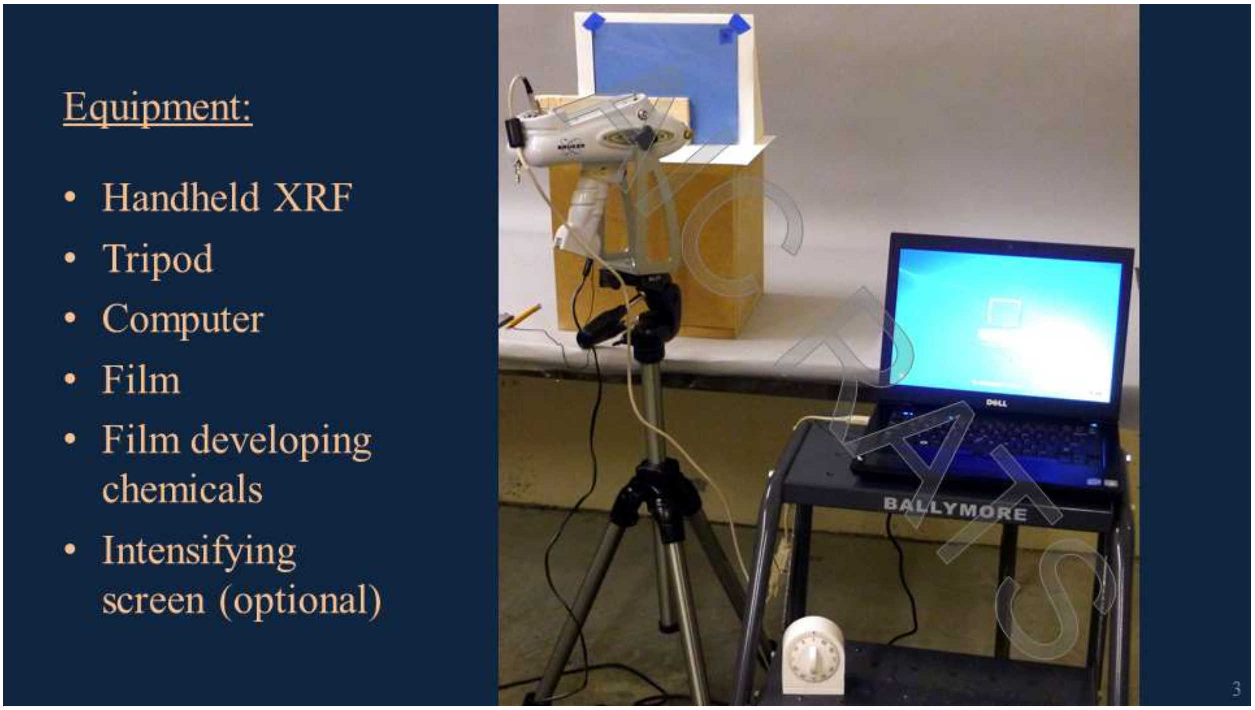
With over 1,200 cultural institutions owning and operating portable X-ray fluorescence (XRF) analyzers, these instruments have become familiar tools for elemental analysis of collection objects. The X-ray source in these instruments can be repurposed for use in X-ray radiography. Successful trials demonstrate this imaging application and suggest the potential for its use on a variety of objects. This radiography method enables portable, small-scale imaging capability without traditional X-ray equipment or beta plates. Tests were carried out using a Bruker Tracer III-V handheld XRF analyzer. This instrument uses an X-ray tube and is capable of producing a voltage range of 0-45kV and an amperage range of 0-60µA. The XRF unit was mounted on a tripod and operated through a computer, allowing the energy levels to be adjusted and the operator to work at a distance from the X-ray beam. The X-ray beam is emitted at approximately 45° relative to the perpendicular of the face of the unit. The instrument was positioned to compensate for this angle, ensuring the object and film were within the beam. An intensifying screen, removed from a film cassette for medical radiography, was used to aid in placement. The intensifying screen is coated with phosphors that convert X-ray energy into visible light, permitting the beam spot size, shape, and location to be viewed in the dark. As with traditional X-ray radiography, the spot-size increases as the distance between X-ray source and target increases, also necessitating a longer exposure. The current in the portable unit is 1,000 times less than in traditional X-ray radiography equipment, and therefore longer exposures are required. Fugi Super HR-T and Kodak BioMax MR films were used and developed in an automatic processor. Recommended safety protocols were followed. X-ray images were successfully produced of paper to record the watermark and wood to evaluate the length of an embedded metal screw. At the following exposures, a working distance of 15 inches resulted in a usable image size of approximately 6 inches in diameter. A sheet of handmade paper with a thickness of 0.008 inches was exposed for 30 minutes at 15kV and 45µA. The resulting image of the watermark and laid lines had less contrast than a beta radiograph of the same sheet, but took less than half the time to produce. A ¾-inch thick block of balsa wood was exposed for 20 minutes at 45kV and 43µA. The wood grain was clearly visible in the X-ray image, as was the presence of an embedded metal screw. More information about the metal screw might be obtained with different operating parameters, but the capacity of the portable instrument may limit the ability to penetrate and record dense materials. Although not suited to all circumstances, this radiography method offers utility, flexibility, and relative ease. A watermark can be recorded without a beta plate; the presence of a pin, crack, join, etc. can be determined without a traditional X-ray imaging facility. The widespread availability of portable XRF units makes such exploratory radiography accessible for a variety of applications.


Using Portable XRF Analyzers for X-ray Radiography
Ashley Jehle - Yale University Art Gallery
Renée Stein - Carlos Museum, Emory University
Maureen Graves - Grady Memorial Hospital
John Malko - Emory University
AIC-CAC Annual Meeting, Montreal
May 16, 2016
AIC RATS



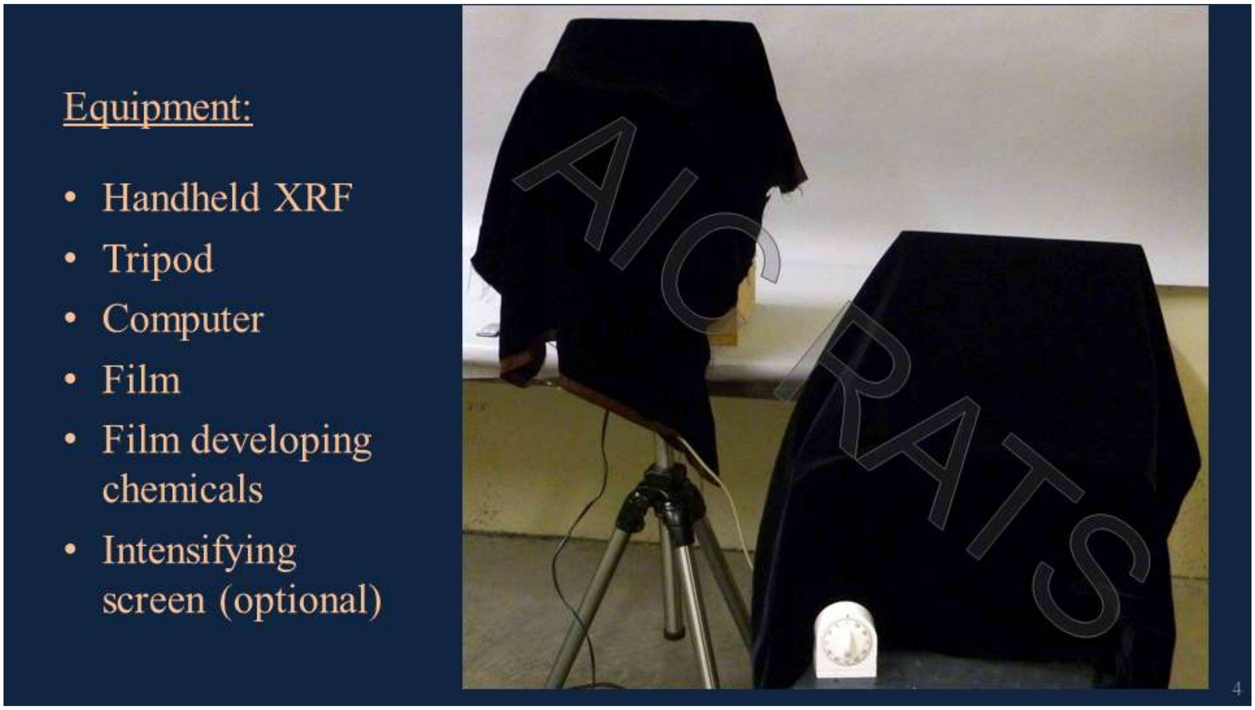
My coauthors and I began exploring this idea of repurposing our portable X-ray fluorescence analyzer, or XRF, for film X-ray radiography because, like many other institutions, the Carlos Museum does not have traditional X-ray equipment in-house. We wondered if the handheld unit could be used for "spot" imaging, to answer an immediate question before, or instead of, transporting the object off-site. Since we, like some other museums, typically collaborate with a nearby hospital, we also wondered if the portable unit would provide the lower energies necessary for imaging paper or other organics, which are often below the threshold of medical equipment. While there are some limitations, we have found this technique can, in fact, be used for small-scale X-radiography of a range of low-density materials.

This presentation covers our work testing this technique; it explains our set-up, shows our results, and discusses some of the limitations and possibilities. I hope to inspire others to experiment with and further adapt this technique.

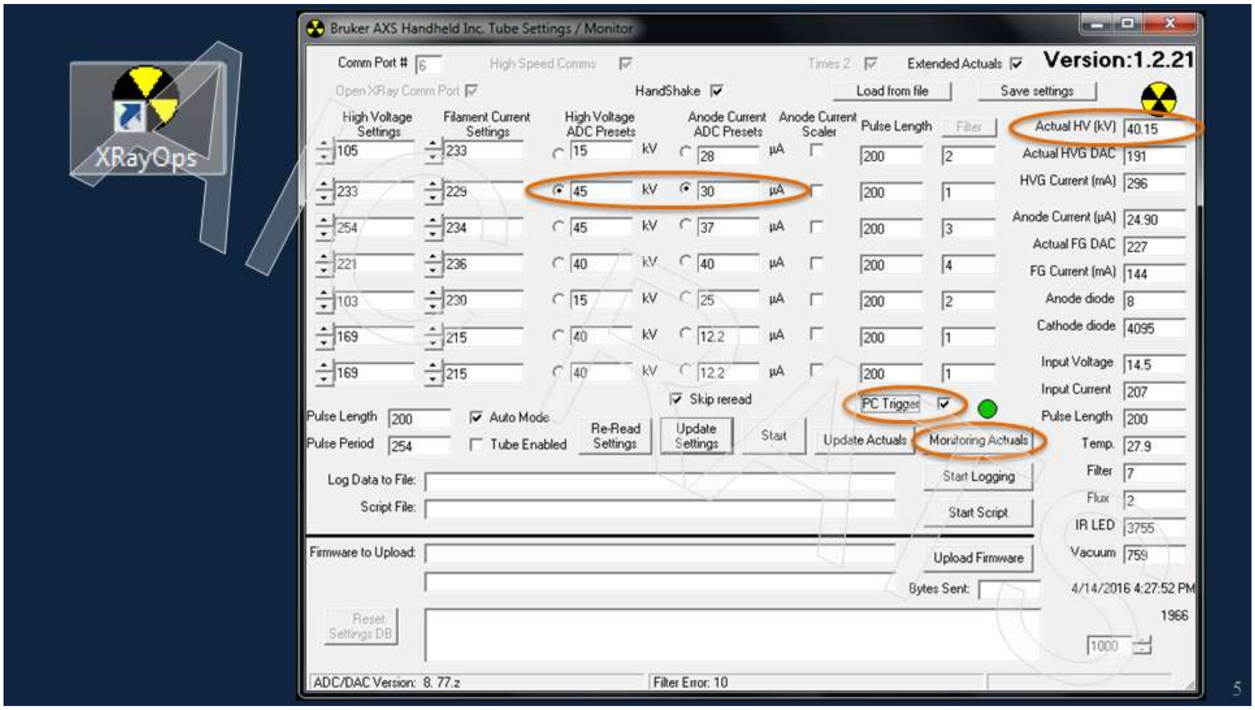


We used a Bruker Tracer III-V, positioned on a tripod and tethered to a computer, to expose medical X-ray film. We placed the film against a rigid support, were mindful of the beam direction, and maintained a secure working area. We were lucky to have access to a dark room and automatic film processor at the Emory School of Nursing, so we were able to develop film quickly. But of course, film developing with inexpensive chemicals in trays is also an option.

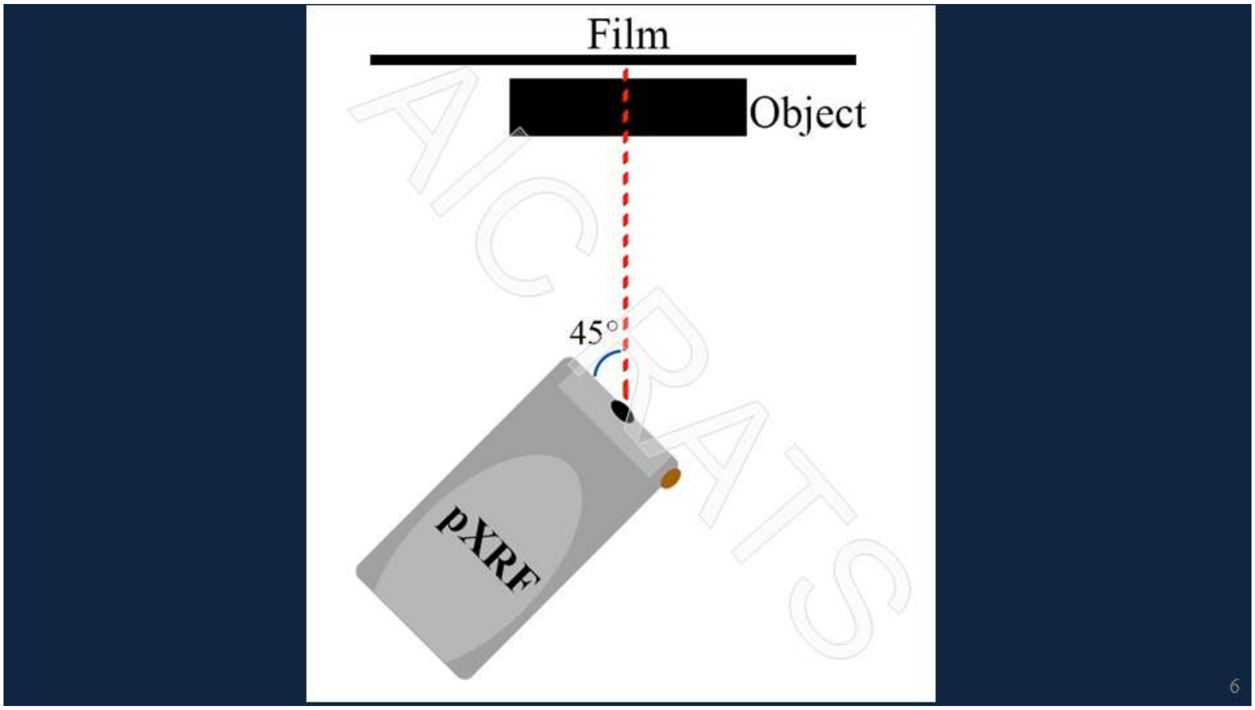
Because X-ray film is also sensitive to visible light and we didn't want interference from using any type of film cassette, exposures were carried out in the dark. We draped dark fabric over the computer, and covered the lights on the XRF unit with metal tape.



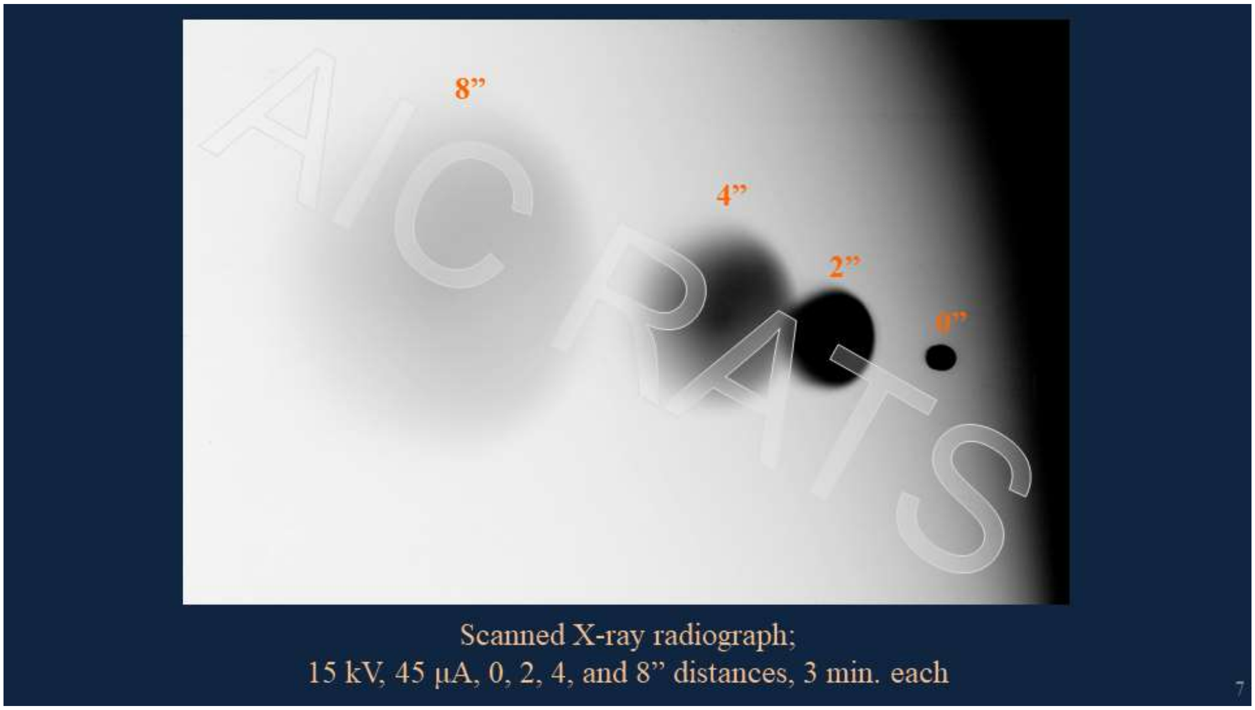
Another option is to also tent the whole set up of the XRF unit, the object, and the film with dark fabric. If the size and stability of the object allows for this, you could then have flexibility to exit the room during long exposures and prevent light fogging the film.



The XRF unit is controlled through a computer, using the Bruker X-ray Ops program. This software is typically used to preset the settings that are utilized by the S1 P-XRF program, which is used for XRF data collection and spectra analysis. Here, I've highlighted some of the useful controls in X-ray Ops. We used this program to adjust the voltage and current and to manually turn the beam on and off for exposure. An external timer was used to track exposure times, since the program does not have this capacity. A nice feature of X-ray Ops is that settings can be saved, so that you can keep your x-radiography settings separate from you XRF analysis settings.



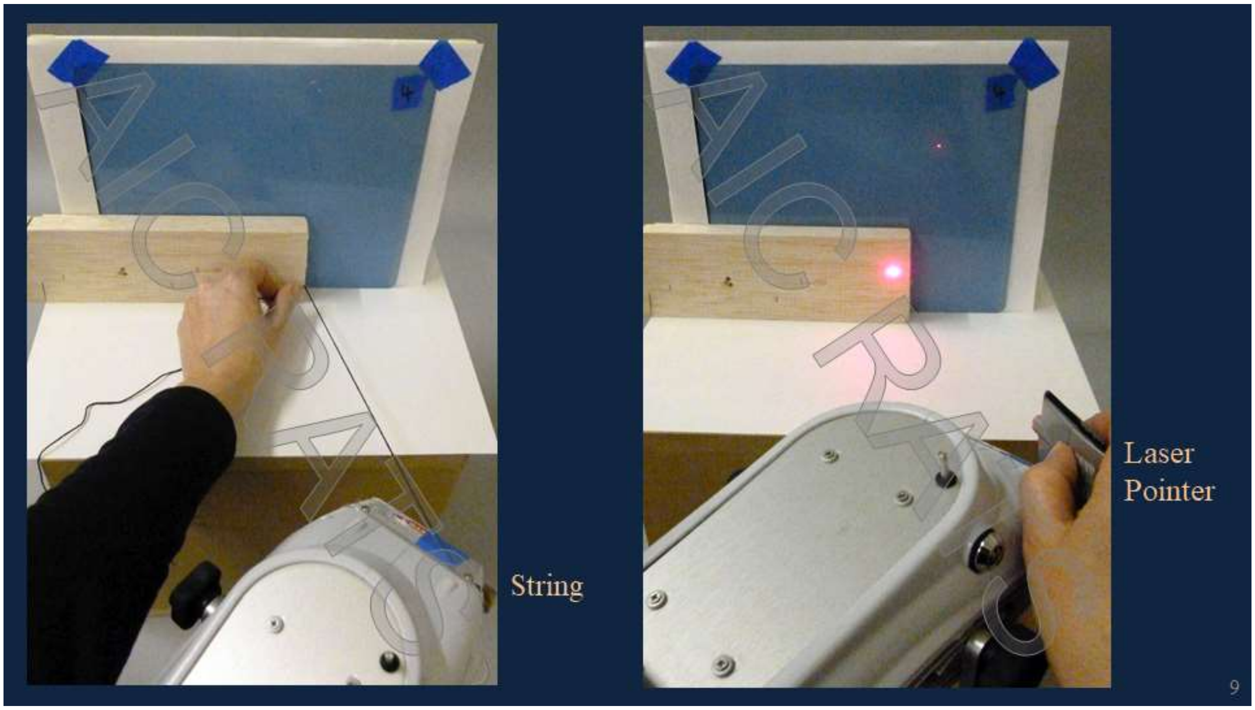
An important feature to keep in mind about the XRF is that the beam is emitted from the unit at an angle. In our instrument, the X-ray beam is emitted at approximately 45°, as illustrated here. This angle is a function of the unit's use in X-ray fluorescence data collection, but we needed to correct for this for our purposes. In this diagram, you can see how we angled the instrument in order to achieve a beam that is perpendicular to the plane of the film.



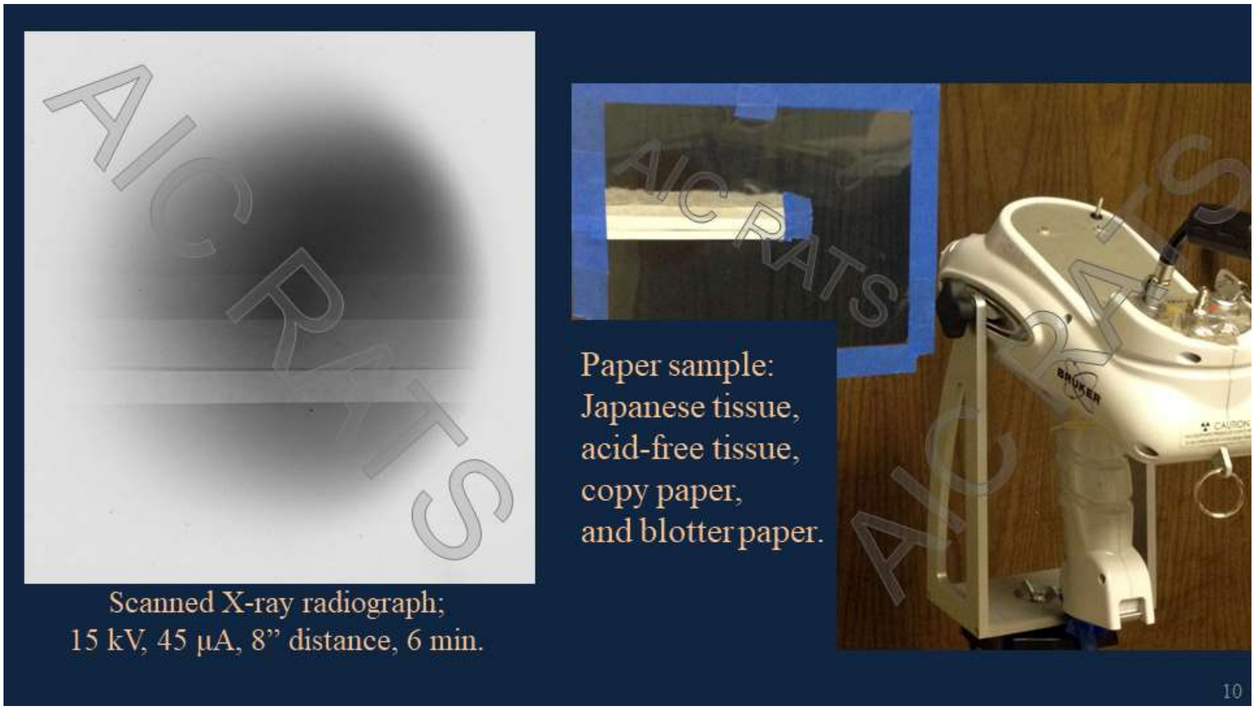
Scanned X-ray radiograph;
15 kV, 45 µA, 0, 2, 4, and 8" distances, 3 min. each

Here is a radiograph of one of our first tests that helps illustrate the beam angle. In this test, we did not angle the instrument, but placed the nose of the instrument directly up to the film. We exposed that area for 3 minutes, and then moved the instrument straight back 2 inches and repeated exposures at different distances. Here you can also see that, as in traditional X-ray radiography, when the distance between the X-ray source and film increases, spot size increases but intensity decreases.

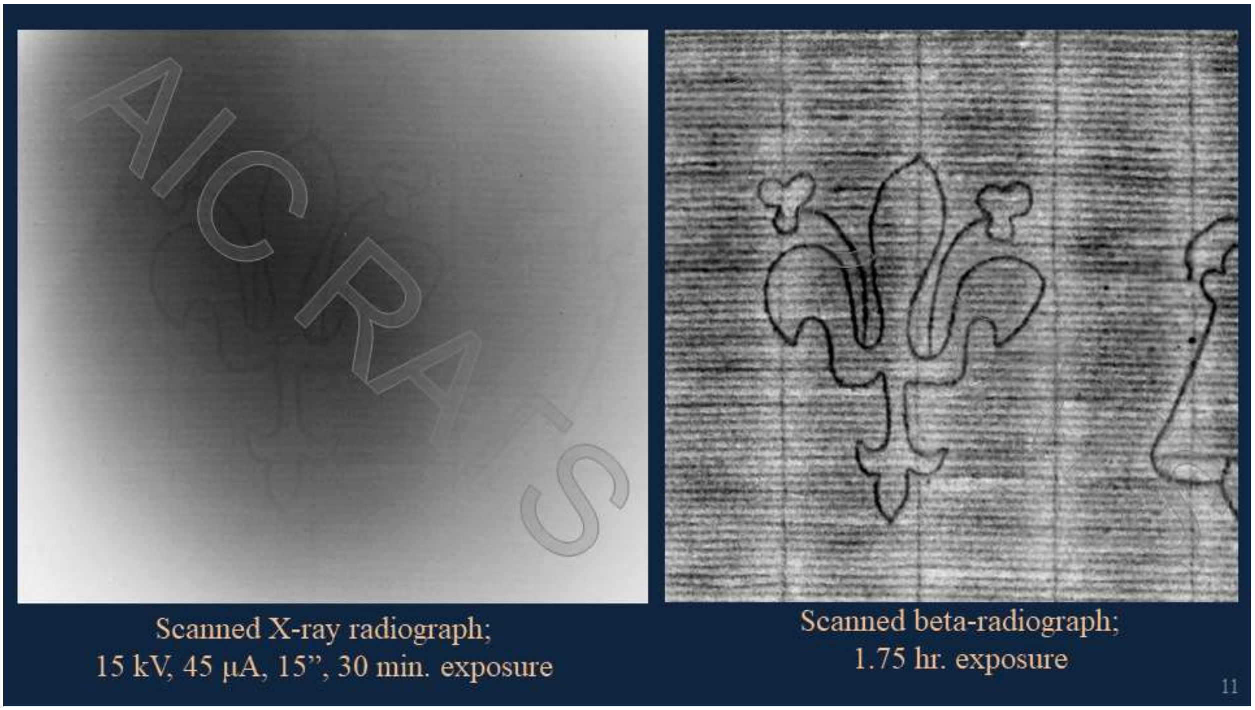
We found an intensifying screen to be a very useful tool to help us estimate this angle and align the beam with the object. This type of screen is used in film cassettes for medical radiography in order to intensify the effects of the beam and reduce exposure time for patients. The intensifying screen is coated with phosphors that convert X-ray energy into visible light, which allowed us to view the beam spot size, shape, and location in the dark. On the right, you can see an image of this – the intensifying screen glows in the dark where it is exposed to the X-ray beam.



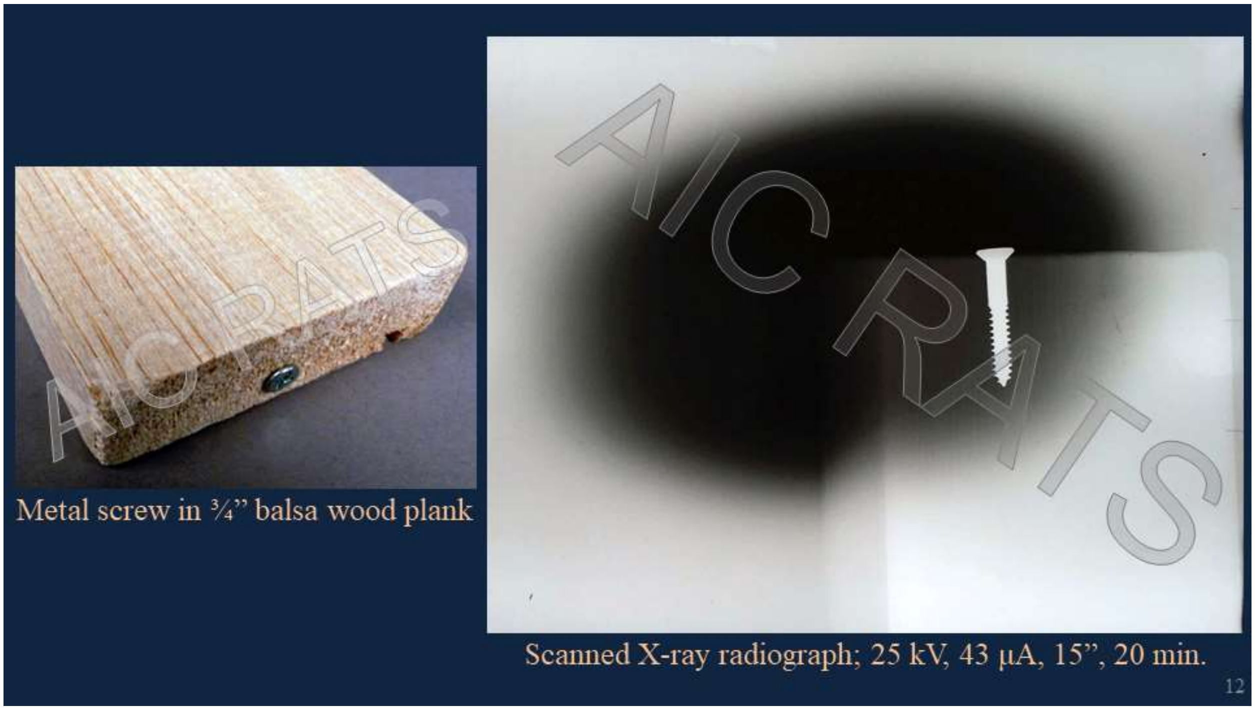
Additional tools can be helpful for aligning the beam with the area of interest on the object. I have used string and angle lines drawn on tape on top of the instrument as guides. Alternatively, a laser pointer is particularly useful, and could even be attached to the top of the instrument like a laser sight. Accommodating the beam angle can be tricky, leading to an elliptical spot-size and the possibly of minor image distortions.



We were initially interested in using this technique for X-radiography of paper, since we knew the energy and intensity produced by the XRF would be lower than that of a traditional X-ray tube. Here, we imaged four paper samples of different thicknesses – you can see the strips of Japanese tissue, acid-free tissue, copy paper, and blotter. The X-ray image on the left was produced at a working distance of 8 inches using 15 kilovolts and 45 microamps with a 6 minute exposure. Note that the current produced by the XRF unit is in microamps, compared to milliamps for traditional X-ray equipment. Therefore longer exposure times are required.

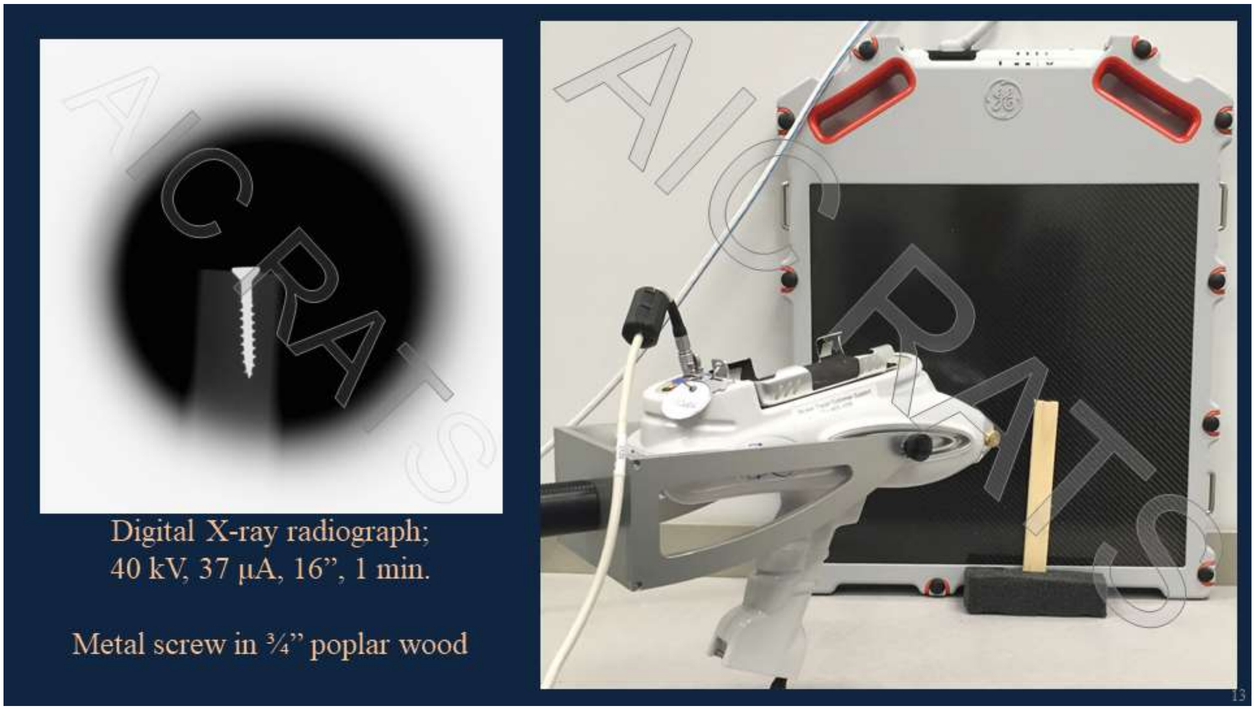


Here you can see the same watermark imaged with XRF X-radiography and with beta radiography. Although this technique cannot reproduce the beautiful contrast and sharpness of beta radiographs, the watermark and laid lines are visible and the exposure took less than half the time to produce. For institutions without access to a beta plate, X-ray radiography with a portable XRF may be a viable option for recording watermarks.

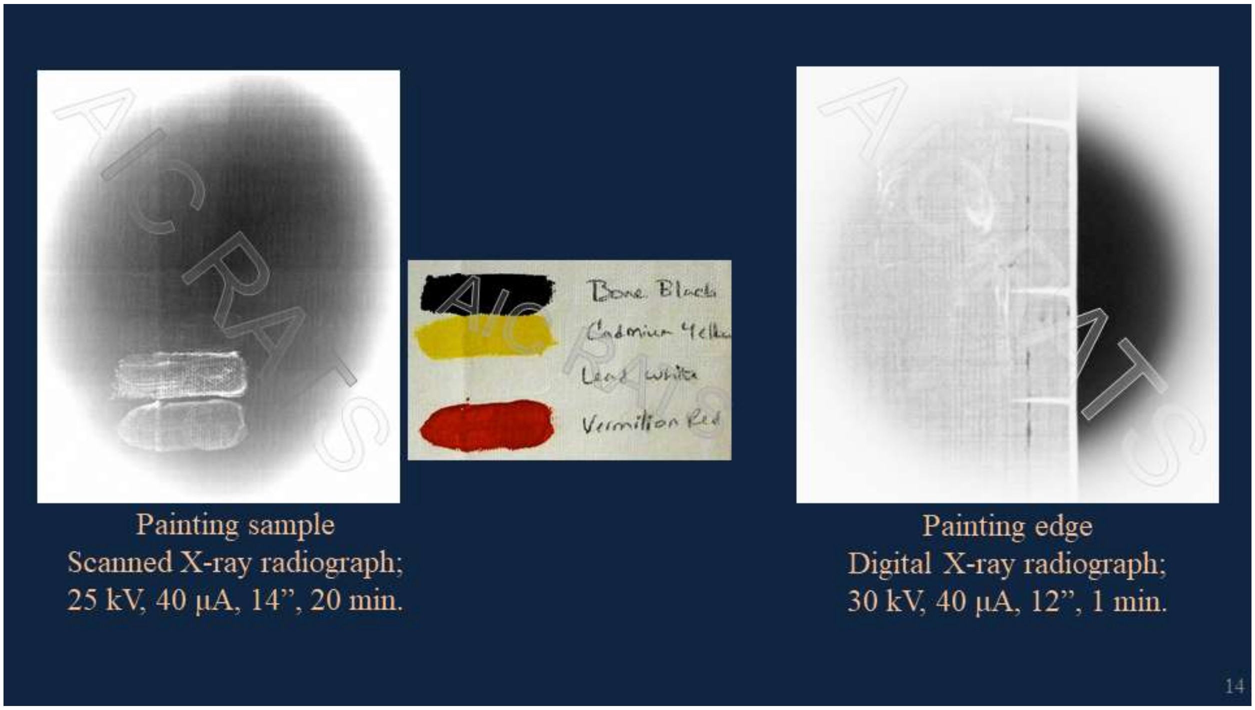


Our XRF unit can reportedly produce voltage up 45 kV and amperage up to 60 microamps, giving this technique potential applicability beyond imaging of paper. Through trials of adjusting settings and monitoring actual readings in X-Ray Ops, we demonstrated the practical limitations of our instrument. We found approximately 40 kV and 30 microamps to be the highest combination of voltage and current possible with our Tracer III-V. Here you can see we imaged a ¾ inch thick plank of balsa wood with a metal screw. This exposure at 25 kV and 43 microamps took 20 minutes, and although it is difficult to see here, the wood grain is visible on the film.

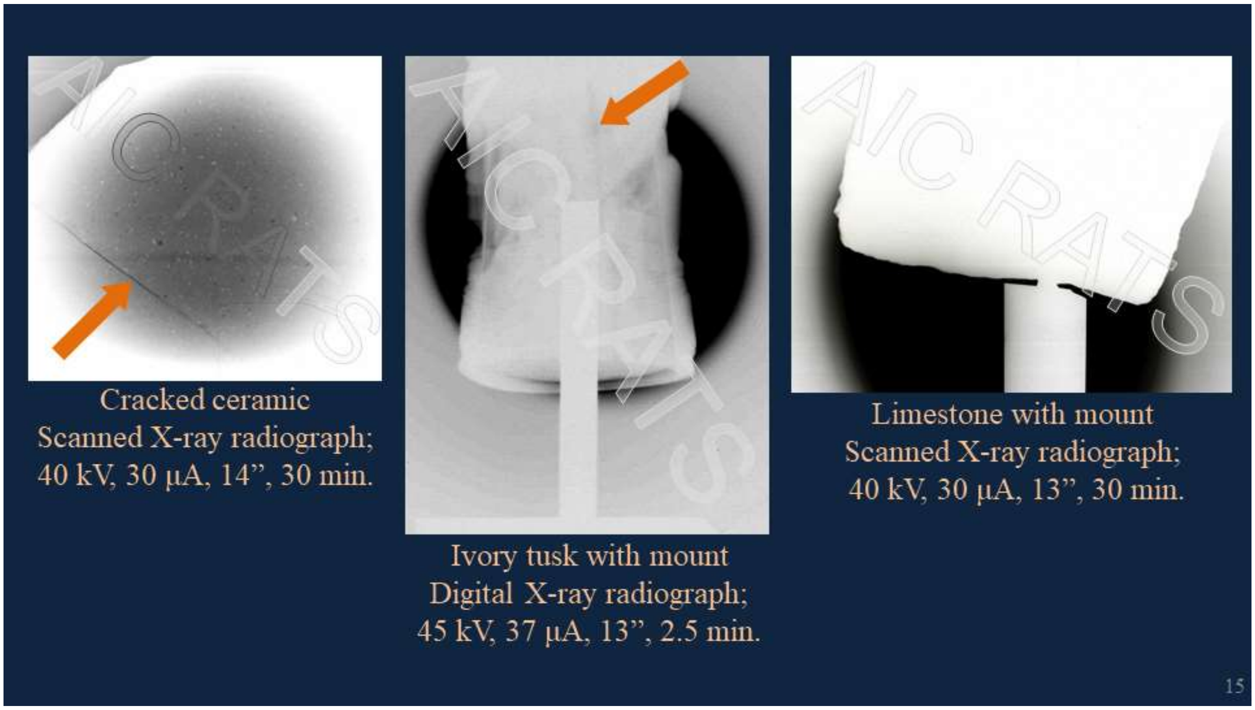
Aside from time, another limitation of this technique is spot size. As with traditional X-ray radiography, the spot-size increases as the distance between X-ray source and target increases. In our tests, a working distance of 15 inches produced an apparent area of exposure between 3 to 6 inches in diameter, depending on the energy settings and film, or recording medium, used. Increased distance also necessitates longer exposure times.



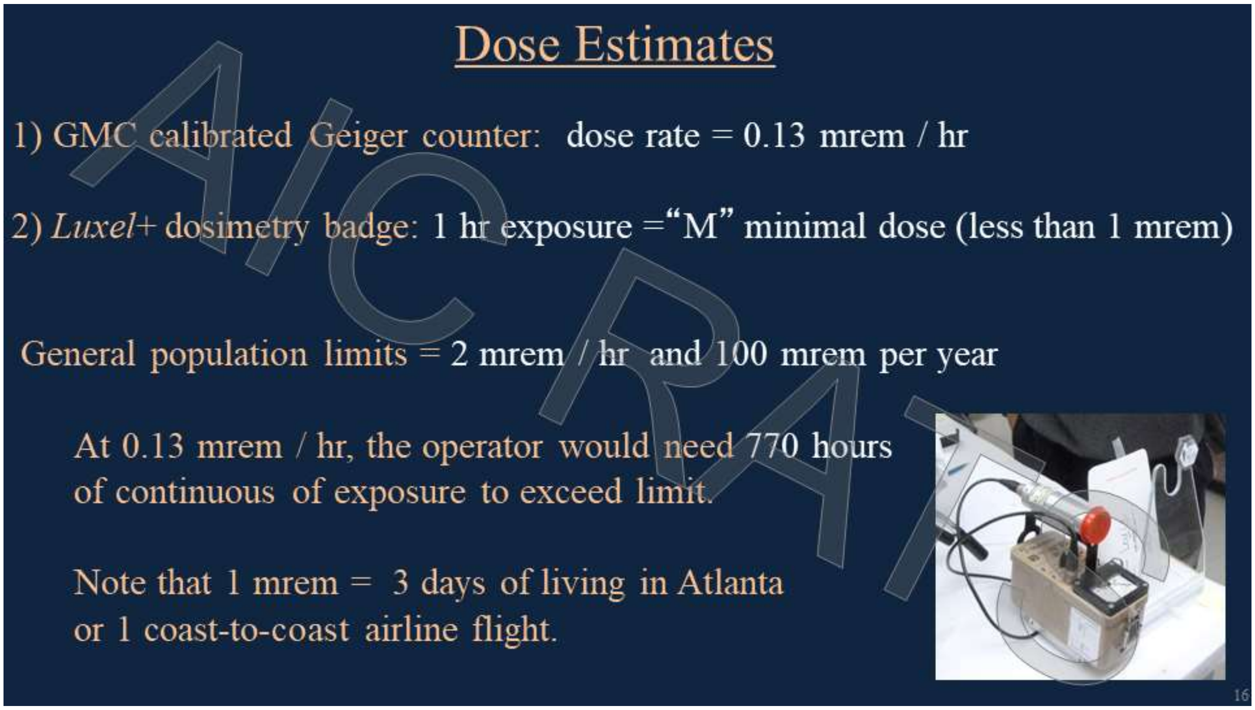
Although this radiography method is probably most useful for those without traditional X-ray equipment, I also tested the technique using a direct-radiography digital plate, also known as a DR system, seen in the image on the right. This technique should also be possible with computed radiography, or CR plate system. The benefits of these recording mediums are shorter exposures, a darkroom is not needed, there is no film processing, and the results are instant. If you have access to a DR system, such as at a local hospital, but their X-ray tube is too powerful for your application, the portable XRF could be used as a lower energy X-ray source.



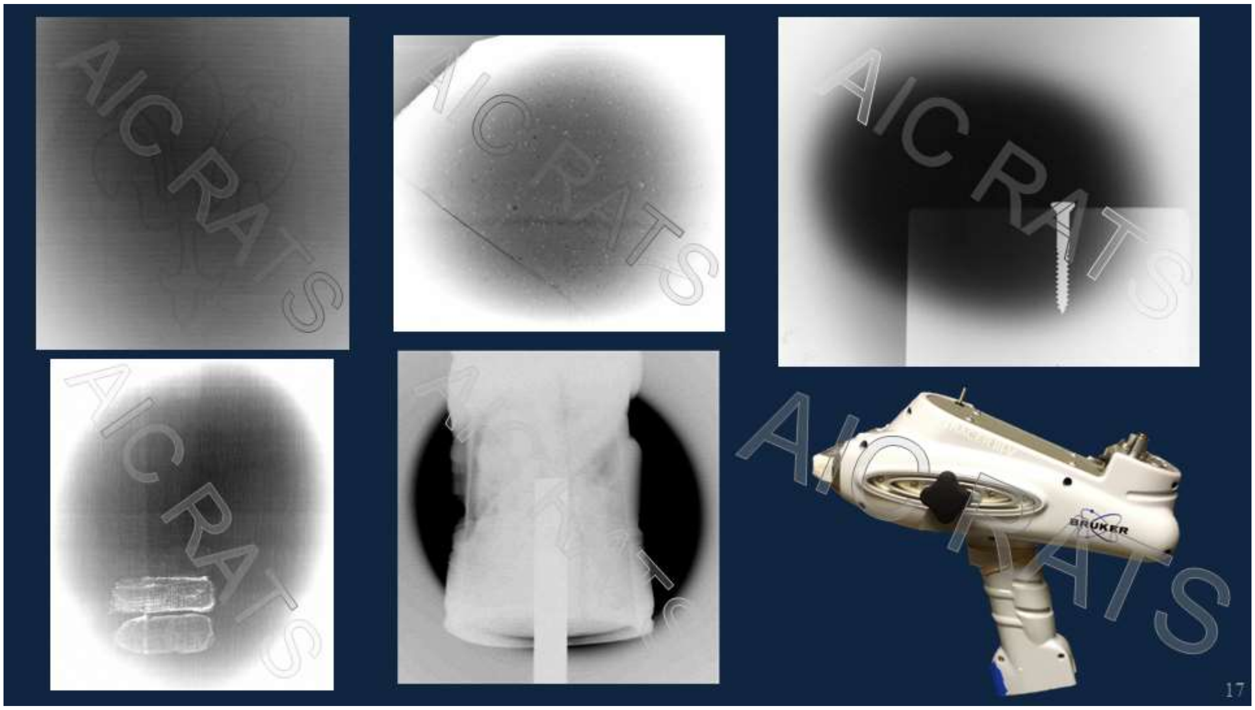
Our continued experiments with other materials and applications helped reveal both the possibilities and limits of this technique. Here we radiographed two different sample painting using film, on the left, and the DR system on the right. In both images you can see the canvas weave, paint strokes, and, on the right, metal tacks are visible at the edge of the painting.



The radiograph on the left shows a crack in an unglazed ceramic, as well as features of the ceramic matrix. In the center image, you see a carved ivory tusk filled with an epoxy-like material, a crack in the ivory, and the metal rod inside. On the right, we attempted to image an embedded brass mount in a 1-inch thick piece of limestone, but the energy capability of XRF unit was not great enough to record the metal inside of the stone.



As with all X-ray producing instruments, the operator should be aware of associated hazards and follow recommended safety guidelines. Since we were using the XRF in a new way, with an open beam and longer working times, we checked the dosage rates. A Geiger counter and dosimeter badge were used to measure and record operator exposures, and we found that although exposure is higher than background levels, it is below the hourly limit by a factor of 16. The operator would require nearly 800 hours of exposure in order to exceed the yearly limit for the general population. Note that 3 days living in Atlanta or 1 coast-to-coast flight, results in 1 millirem of radiation exposure, which is significantly more exposure than operating the XRF instrument for 1 hour.



As you can see, a handheld XRF analyzer can be used for small-scale X-ray radiography. Although the capacity of the portable instrument may limit spot size and the ability to penetrate and record dense materials, radiography of a range of materials including paper, paintings, wood, and other low-density organics, is possible. And the presence of a pin, crack, or join may be determined without expensive, traditional X-ray equipment and without transporting the object to an imaging facility. The widespread availability of portable XRF units makes such exploratory radiography accessible for a variety of applications. We hope that others will now continue to experiment with imaging set-up, film types, and applications for use of this technique.

My co-authors and I would like to acknowledge the support of our colleagues and institutions. I began this project as an Andrew W. Mellon Fellow at the Carlos Museum and continued experimentation during my fellowship at the Yale University Art Gallery.

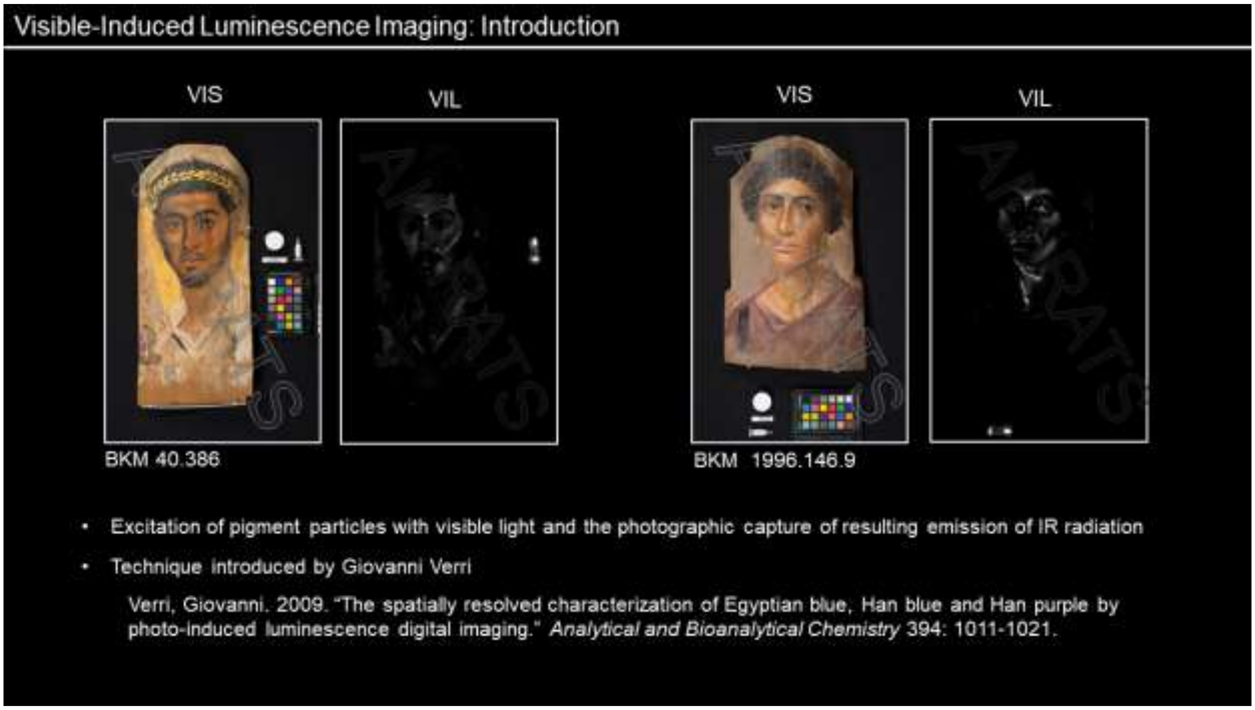
Visible-Induced Luminescence Imaging: Past, Current and Future Applications in Conservation Research

Giacomo Chiari, Dawn Lohnas Kriss, Caroline I. Roberts, Anna Serotta, Marie Svoboda

Abstract

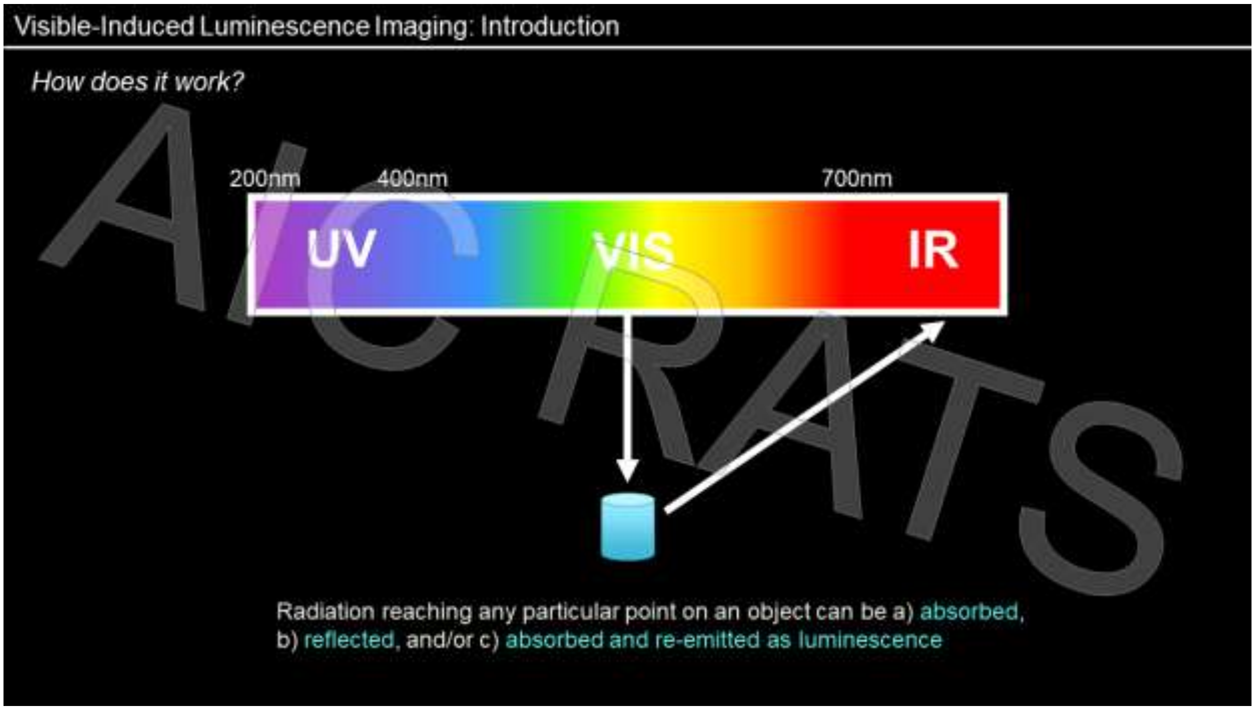
Multispectral imaging (MSI) has seen a rapid development within the field of conservation, thanks in part to its adaptation with digital imaging techniques. One recent advance in MSI is the use of visible-induced infrared luminescence (VIL) to map pigments that might otherwise be invisible to the naked eye. This technique, first published by Giovanni Verri (2009), involves the excitation of pigments on object surfaces with visible light, and the photographic capture of the resulting emission of infrared radiation. Specific pigments, including Egyptian blue, Han blue, Han purple, cadmium red and cadmium yellow, emit infrared radiation when excited in the visible range, creating visible-induced luminescence. The ways in which this phenomenon can be captured in an image involve a wide range of photographic equipment and associated techniques, which will be the focus of this paper. The authors will discuss their own experiences at the Metropolitan Museum of Art and the J. Paul Getty Museum Villa, where this technique has been used on a wide range of projects, including both in-lab and in-gallery imaging campaigns. Conservators have also tested the technique on archaeological excavations and have found that with the right equipment (battery-powered, durable) and the ability to limit ambient light, VIL can be successfully carried out in less controlled environments. This paper will provide a review of previous and current methodology, including a discussion of image capture and processing trade-offs, and also highlight areas for future development and experimentation.

The goal of this presentation is to critically assess Visible Induced Luminescence Imaging methodology. This imaging technique, like all imaging methods, cannot be a standalone method for materials identification, but as you will see during this presentation, it can be an effective first step to inform more in-depth research.

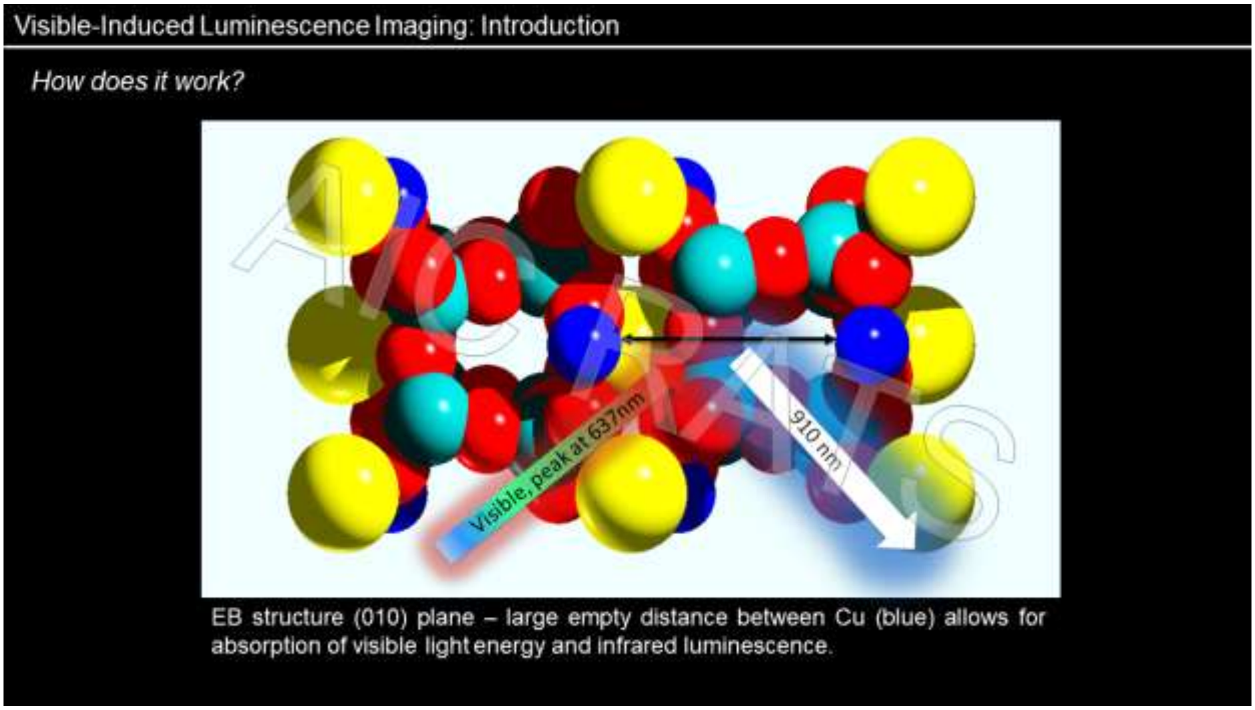


Visible-Induced Luminescence Imaging, known as VIL for short, was introduced by Giovanni Verri in 2009, and involves the excitation of specific compounds with visible light, and the photographic capture of the resulting emission of infrared radiation. Specific pigments, including Egyptian blue, Han blue, Han purple, and some cadmium pigments, emit infrared radiation when excited in the visible range, creating visible-induced luminescence. While VIL is used by many of our colleagues, there is substantial variation in capture and processing methodology. To better understand how this technique was being used, we conducted an online survey to gauge current use in our field, which we'll refer to throughout the presentation.

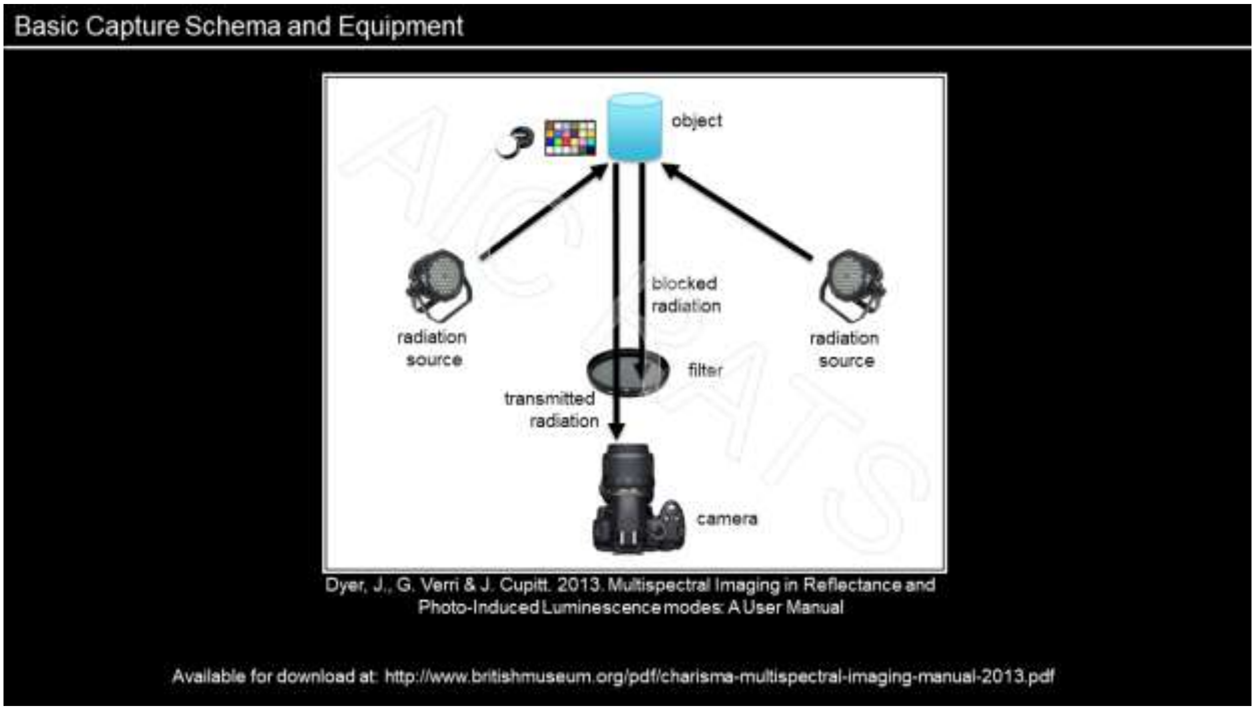
VIL can be especially helpful in identifying trace pigment particles. At the New York University excavations at Selinunte, for example, it has become common practice to image terracotta sculpture and architectural fragments that come out of the ground, prior to cleaning. This technique can not only visualize particles, but is helpful for mapping their location—as seen with this Egyptian blue necklace (on the right), which was virtually invisible to the naked eye!



How does this technique work? Radiation reaching an object surface can be absorbed, reflected, and/or absorbed and re-emitted as luminescence. In the case of VIL, pigment particles absorb visible light and re-emit luminescence in the infrared.

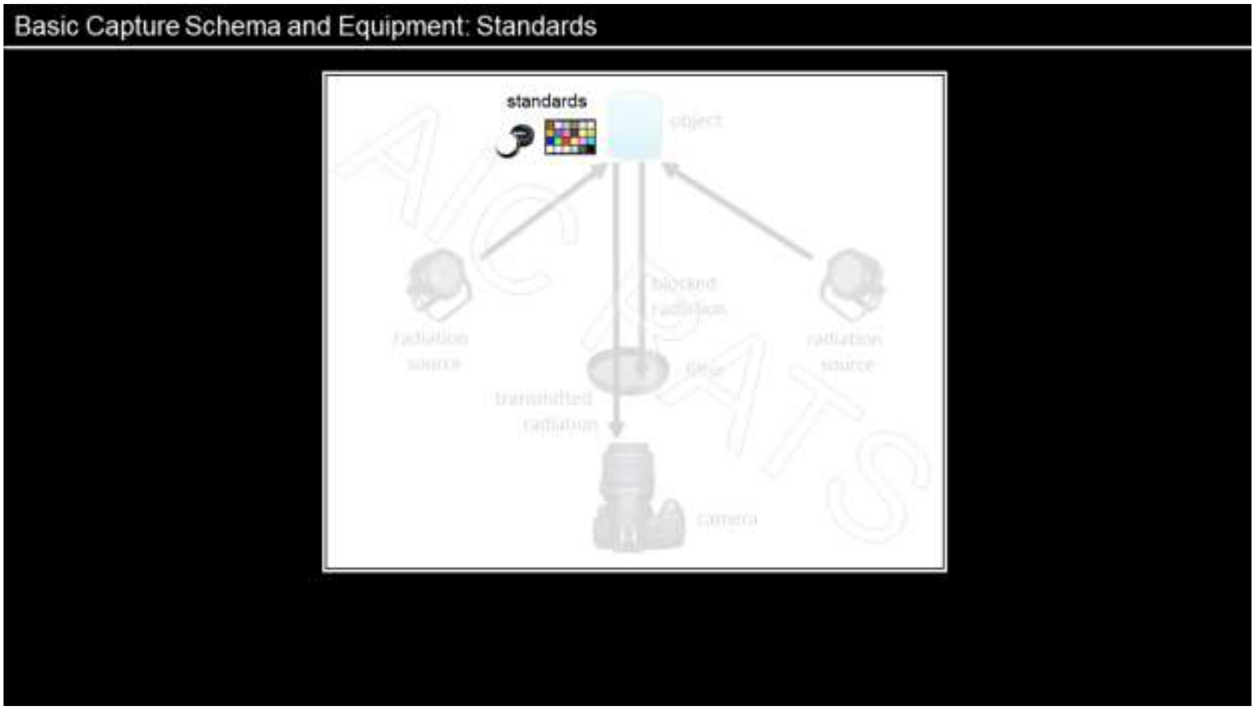


For example, Egyptian blue luminesces because the large empty distance between the dark blue copper ions allows for the absorption of visible light energy and the re-emittence of that energy as infrared luminescence.

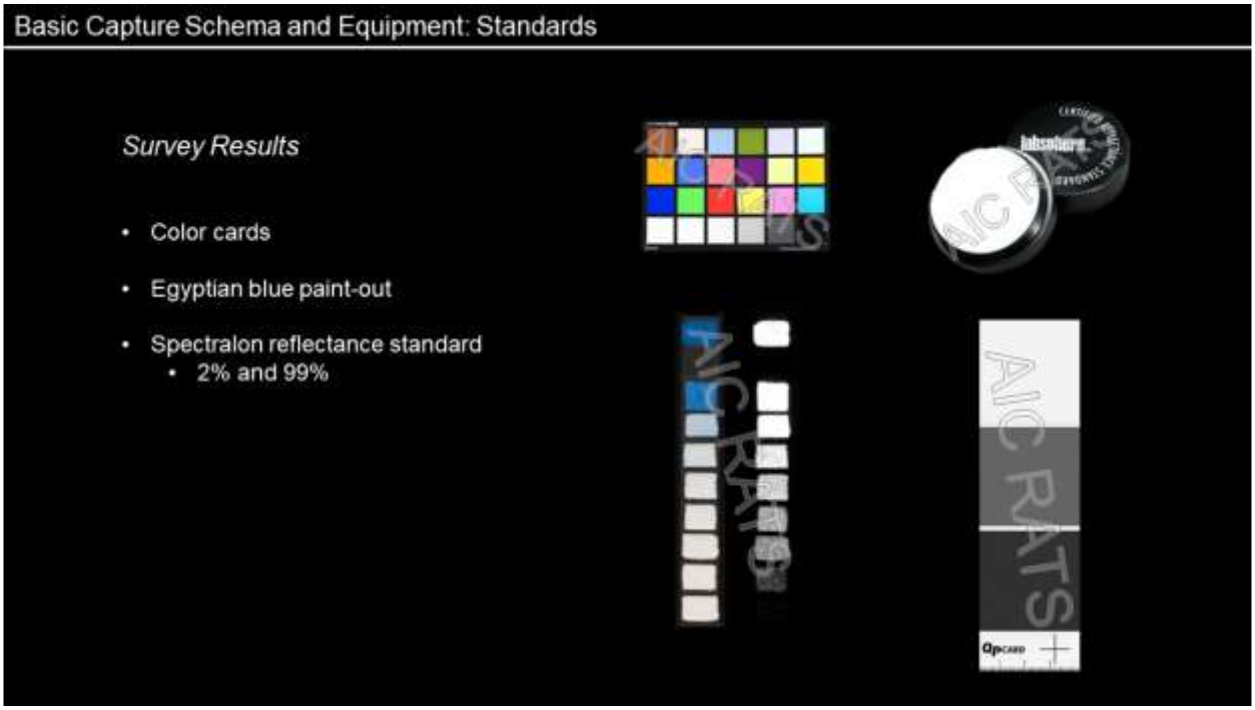


Our VIL protocol is based on capture and processing standards outlined in the CHARISMA technical imaging protocols, developed by a group at the British Museum. The result has been the creation of an in-depth User Manual and post-processing software for multiband imaging. We adopted the protocols outlined in the CHARISMA manual in the Objects Conservation Department at the Metropolitan Museum of Art and then in the Conservation Department at the Brooklyn Museum. There are other approaches, however, which we will discuss as well.

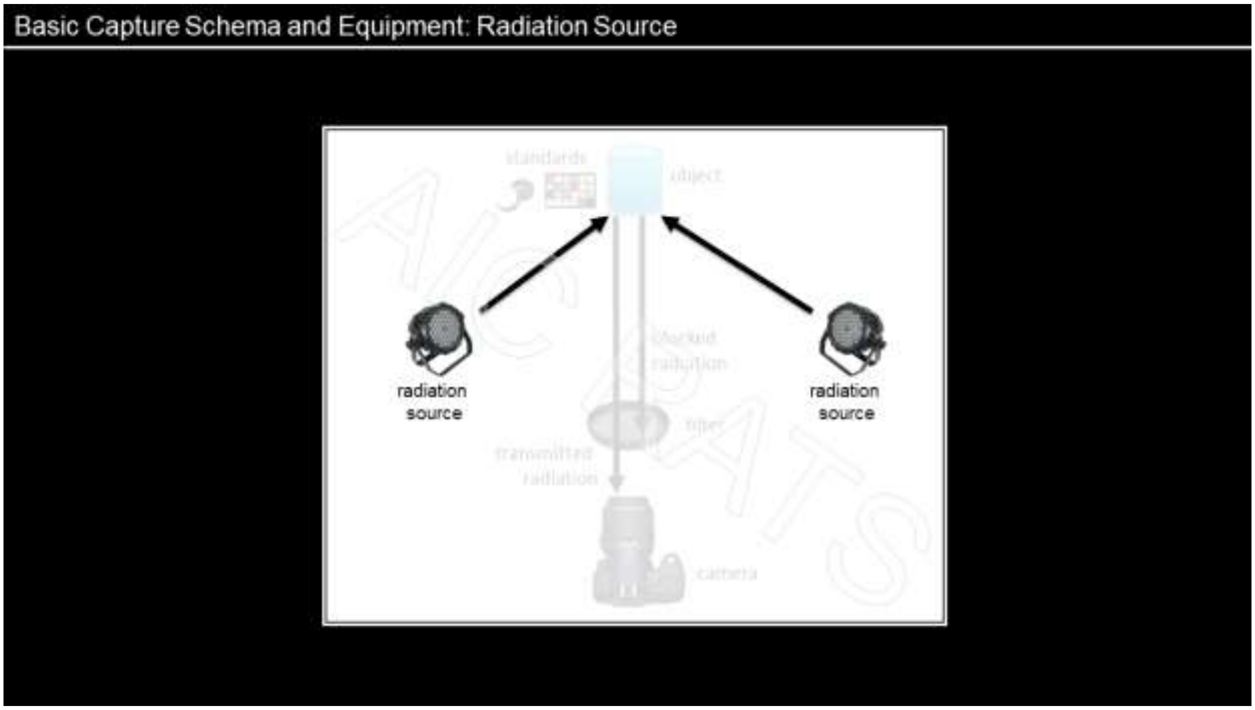
Here you can see the basic set-up schema that we recommend with a DSLR camera, IR longpass filter, radiation sources and imaging standards.



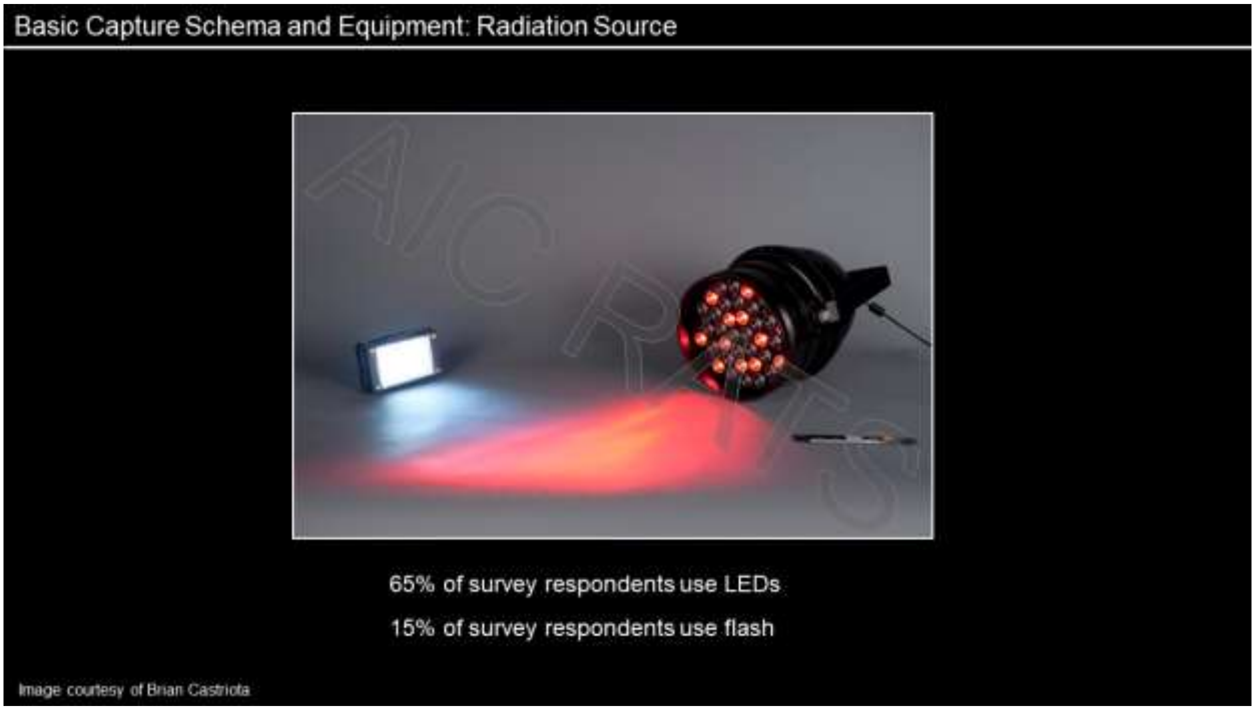
First lets discuss standards, which are included in the photographed image as a reference.



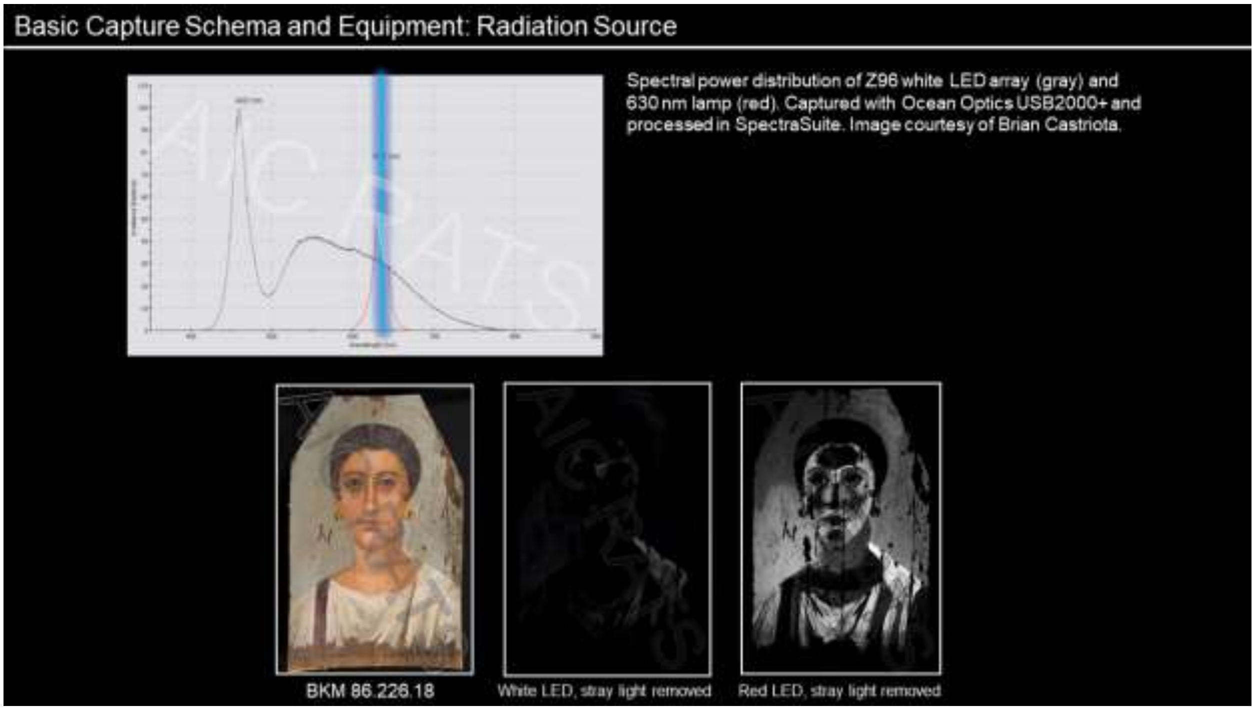
Over 75% of survey respondents doing VIL are shooting with standards. 2/3 of them use a pigment standard or mockup to help to judge relative luminescence. Approximately 1/3 are using Spectralon reflectance standards. These allow for luminance calibration of reflected images and detection of the presence of ambient stray radiation in luminescence images and have a certified spectral flatness over the UV-VIS-NIR spectrum, which is why they are recommended in the CHARISMA protocol.



In terms of visible radiation sources, there are many possibilities. In some cases, the same light sources can be used for both VIS and VIL, though there are advantages and disadvantages to choosing some of these light sources, which we will now touch on.



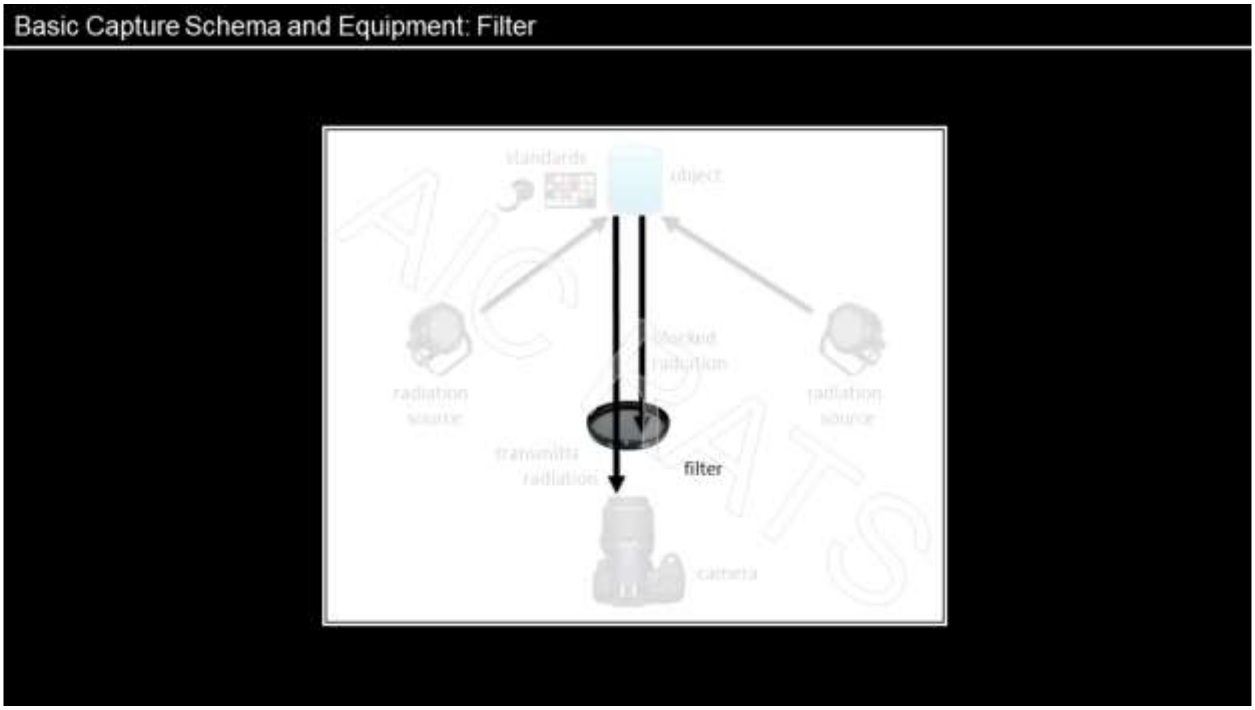
Our survey respondents are using a range of different visible light sources, including the Crimescope tunable light source, digital projectors, xenon lights, Elinchrome strobes, filtered flashes, and LEDs.



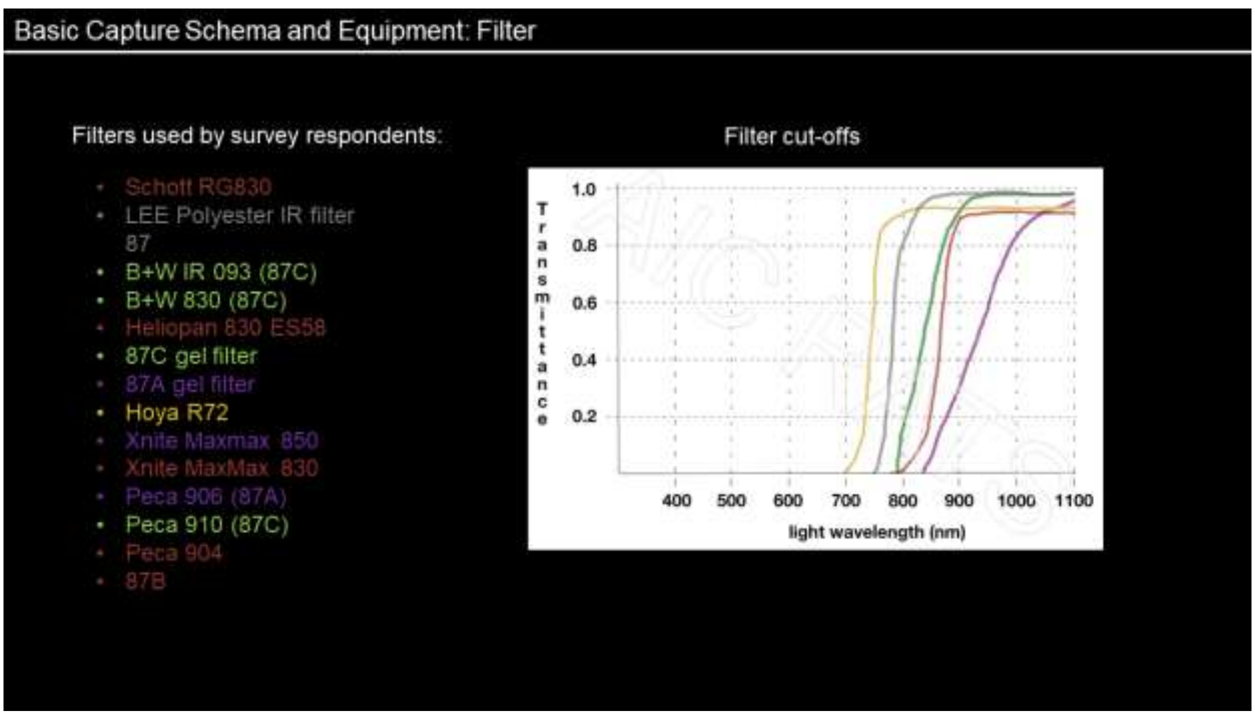
In 2012 Brian Castriota compared a white LED array and a red LED lamp at the New York University IFA Conservation Center for the imaging of Egyptian Blue. He found that despite the white LED output being stronger, the red LED induced more luminescence. This is because the peak excitation of Egyptian blue occurs around 637nm, and that is the red light's peak output.

As you can see here, the red LED induced luminescence much more strongly than the white LED, even when examining the image more closely, pixel by pixel.

However, there are two important variables when choosing a light source: spectral range and intensity of light. So, for example, a strong RGB or white LED may out-perform a weak red LED.

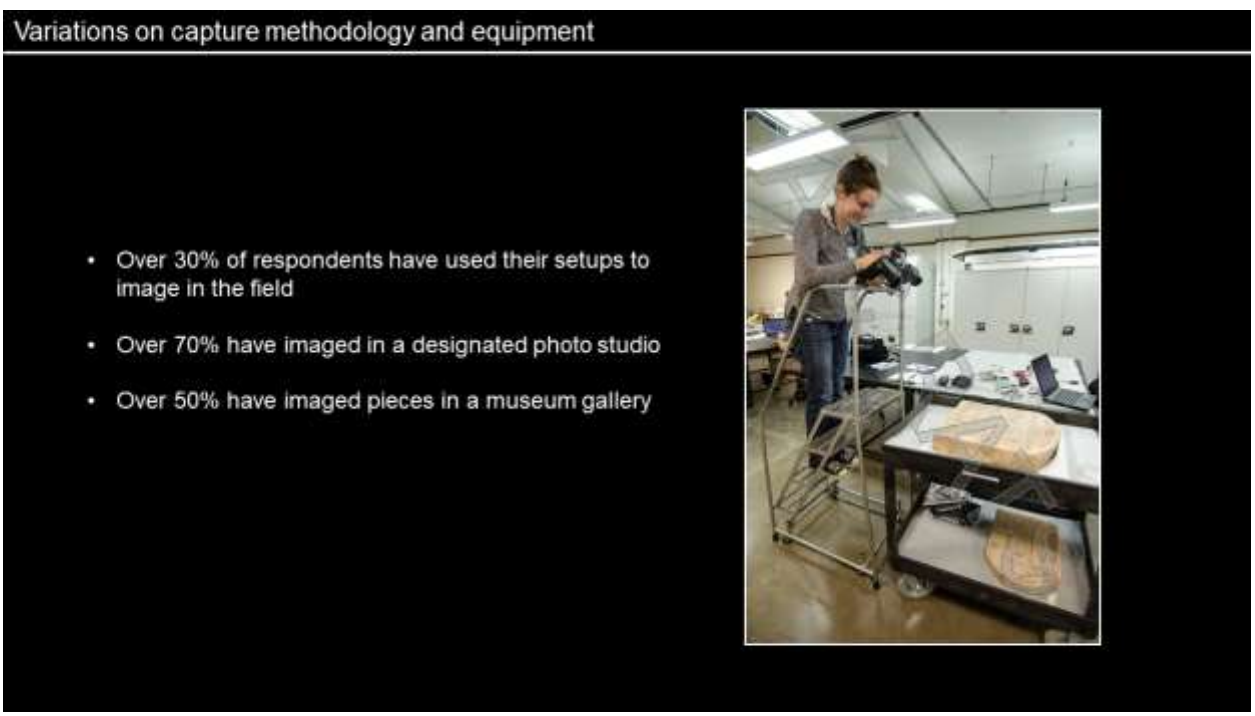


Just a brief note about filters.

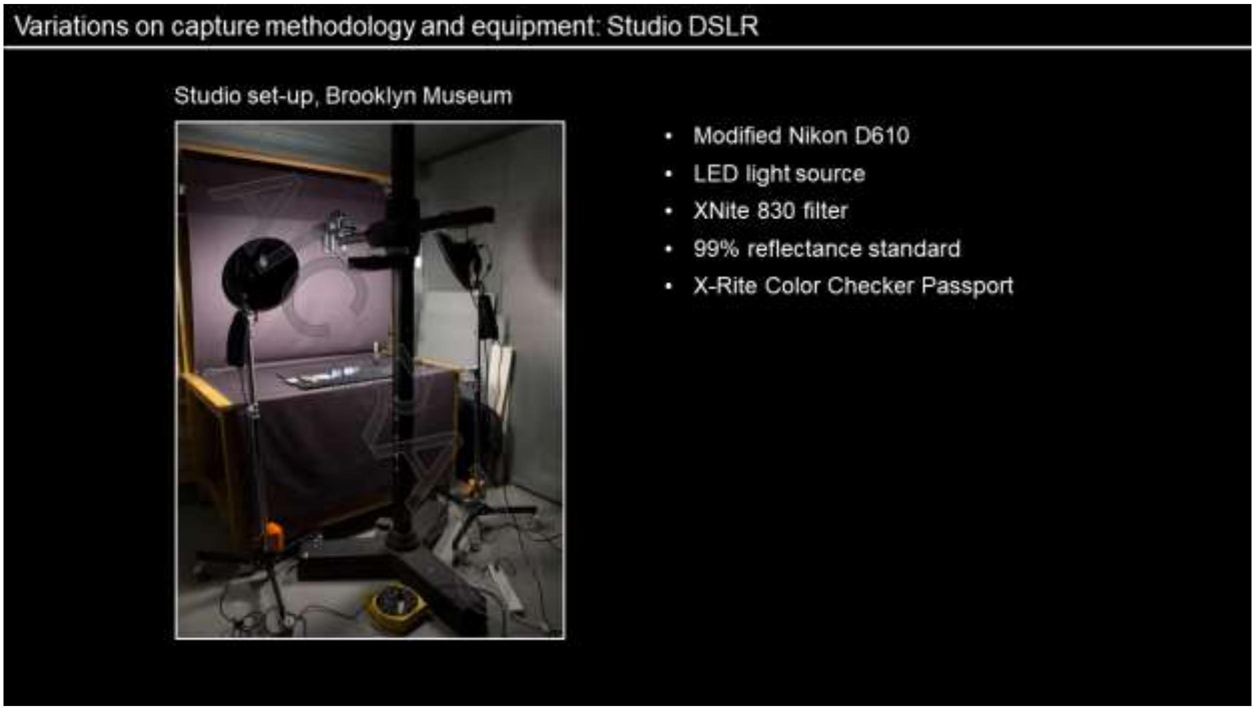


Our survey found a range of filters being used. Essentially, because we are capturing in the IR, what is needed is a longpass filter that blocks light below the IR range, though it might be interesting to compare images captured with different filters in the future.

In terms of cameras, any camera with its normal internal IR filter removed will work. And of course, the higher the quality of the camera, the higher the resulting quality of the images. For this reason, the use of a DSLR may be preferable when conditions allow.



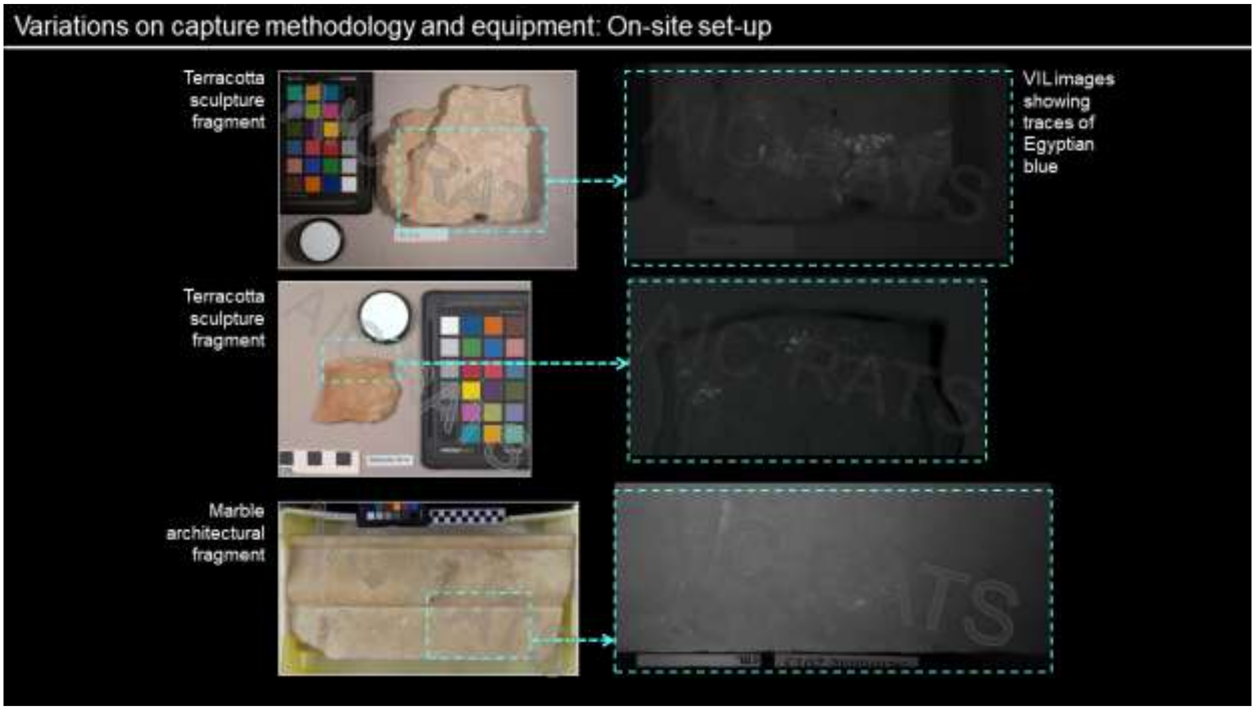
While there can be significant variation in equipment selection between institutions, one of the great things about this imaging method is its adaptability. Survey respondents used VIL in studio, field and gallery settings.



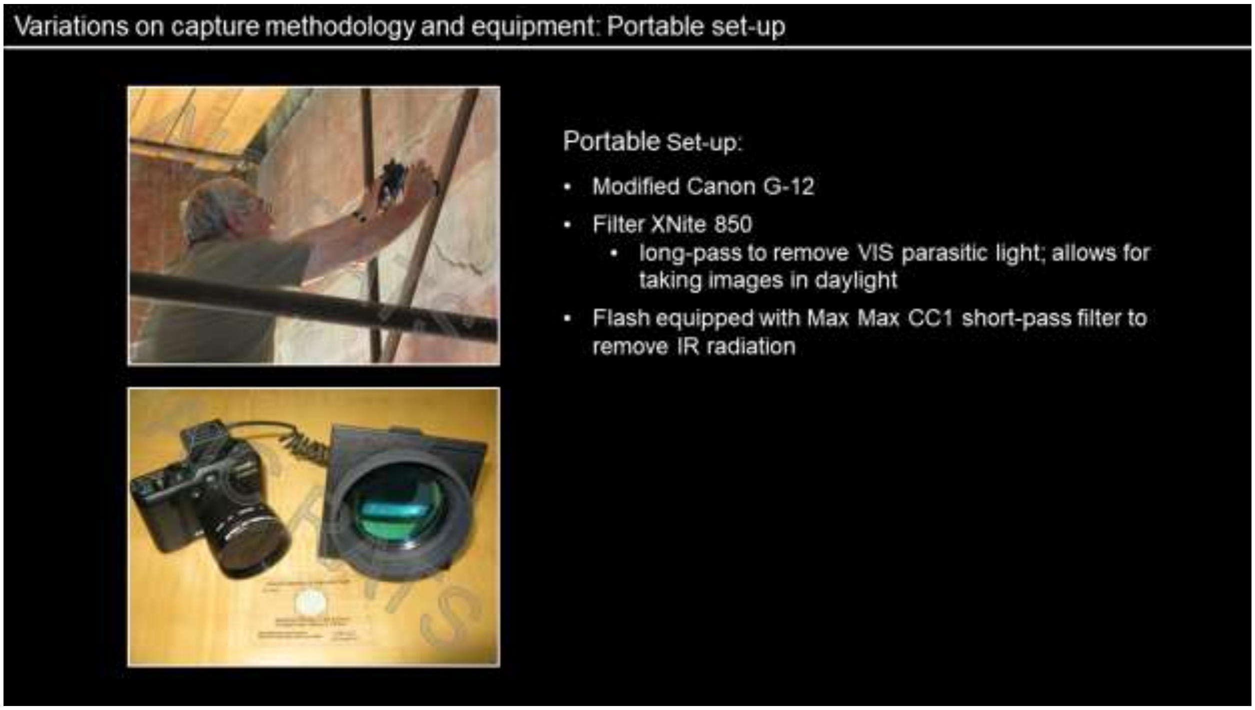
Here is our set-up at the Brooklyn Museum. We shoot in our imaging studio using a modified DSLR with an XNite 830 filter, a 99% reflectance standard, an XRite color card, and an Egyptian blue paint-out strip (we'll return to this a bit later). While we began shooting with white LED light sources, because of the difference seen in the excitation with the red light, and the spectral distribution of our lights, we are now switching over to RGBs.

In the Objects Conservation Department at the Metropolitan Museum of Art, the set-up is essentially the same . VIL is typically carried out in the department's photo studio using the same set of equipment, including an RGB LED (disco light).

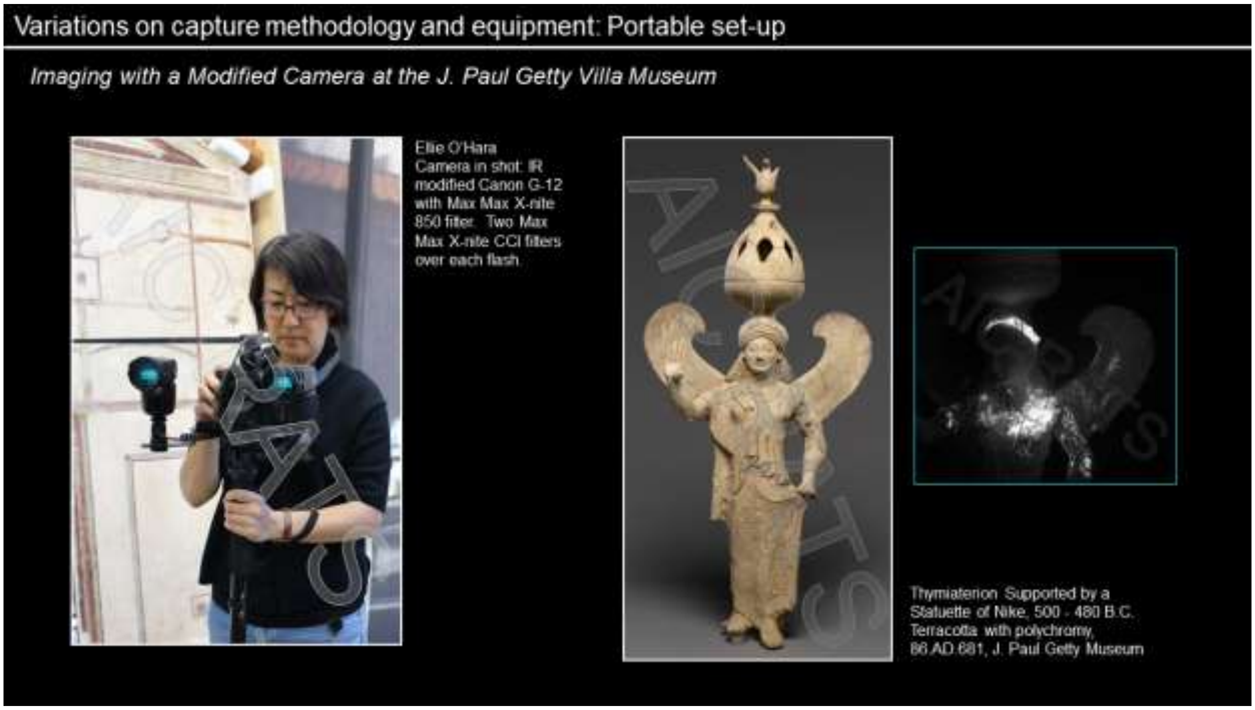
VIL is also readily adaptable for field applications. At NYU's excavations at Selinunte, our field set-up includes: a modified DSLR, a battery-powered white LED (for the purposes of portability), a filter, and reference standards. It's impossible to cut out all ambient light in our workspace, but black cloth draped over the windows has been sufficient.



We already showed you the dramatic image of the terracotta figurine with the necklace, but sometimes subtle results are no less important in understanding patterns of polychromy in the material culture from this site.

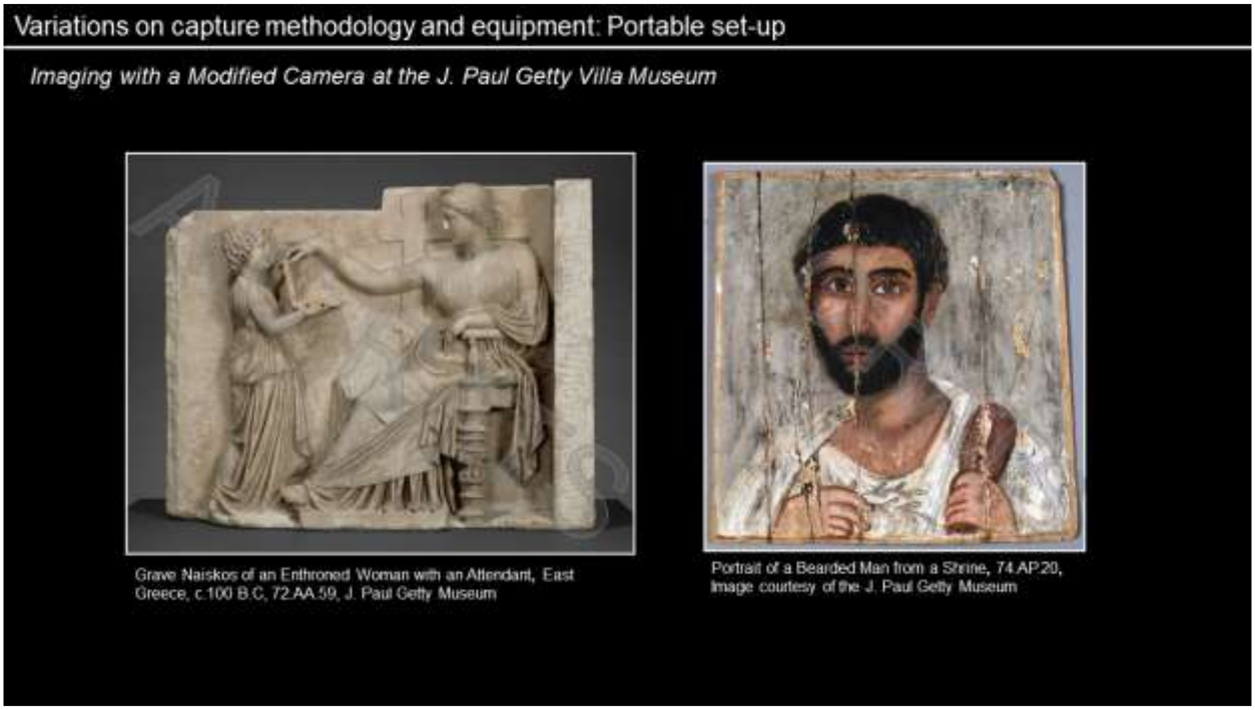


At the Getty Conservation Institute, a different variation on the mobile set-up was developed by our co-author Giacomo Chiari for use in the field. This set-up uses a modified Canon G-12 (not a DSLR), an XNite 850 long-pass filter which removes stray light and allows for image capture in daylight, and a flash with a Max Max CC1 short-pass filter to remove IR radiation. So, this set-up controls both what is coming out of the light source and what is going in to the camera.

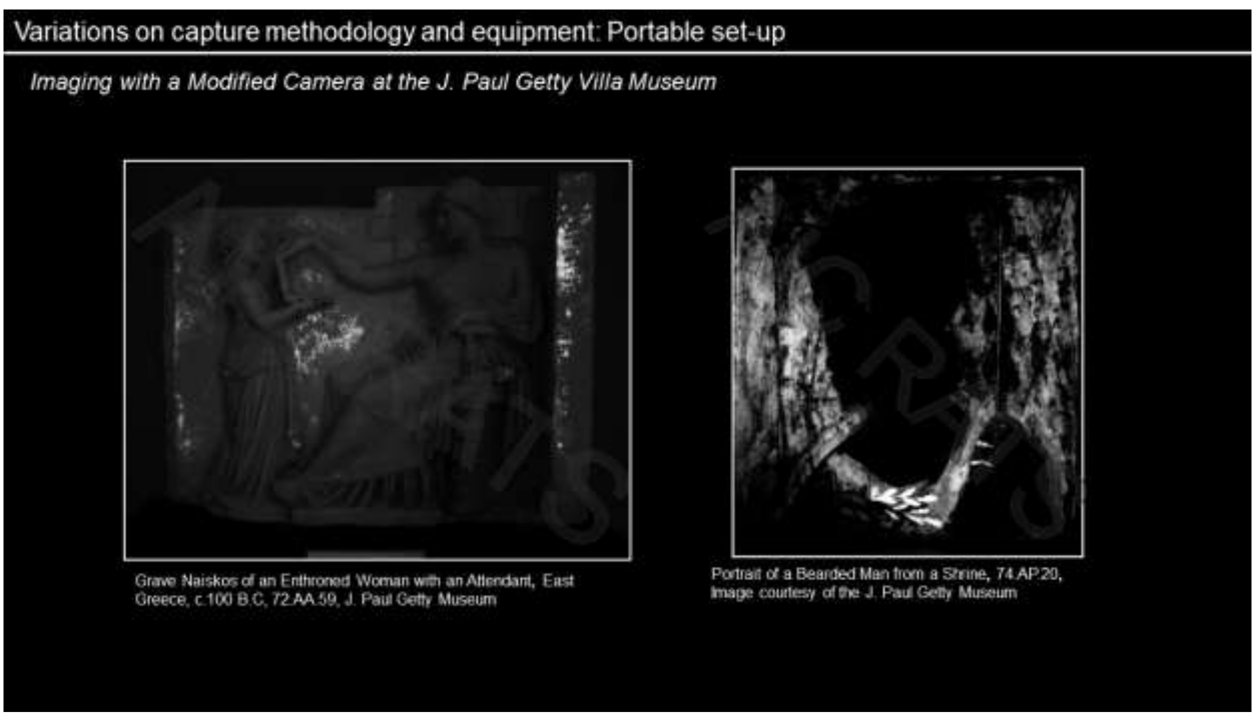


Here is a variation on the set-up with two flashes attached to the camera. An IR modified Canon G-12 is used with a with Max Max X-nite 850 filter. Note that there are two Max Max X-nite CCI filters over each of the flashes.

The assemblage can either be hand-held or it can be attached to a monopod or tripod. Obvious advantages to using a tripod or monopod are the ability to shoot with a slower shutter speed and the ability to take a visible light shot in the exact same position as the VIL image. However, a hand-held set-up gives the user the ability to shoot in spaces that are tricky to access with more cumbersome equipment.

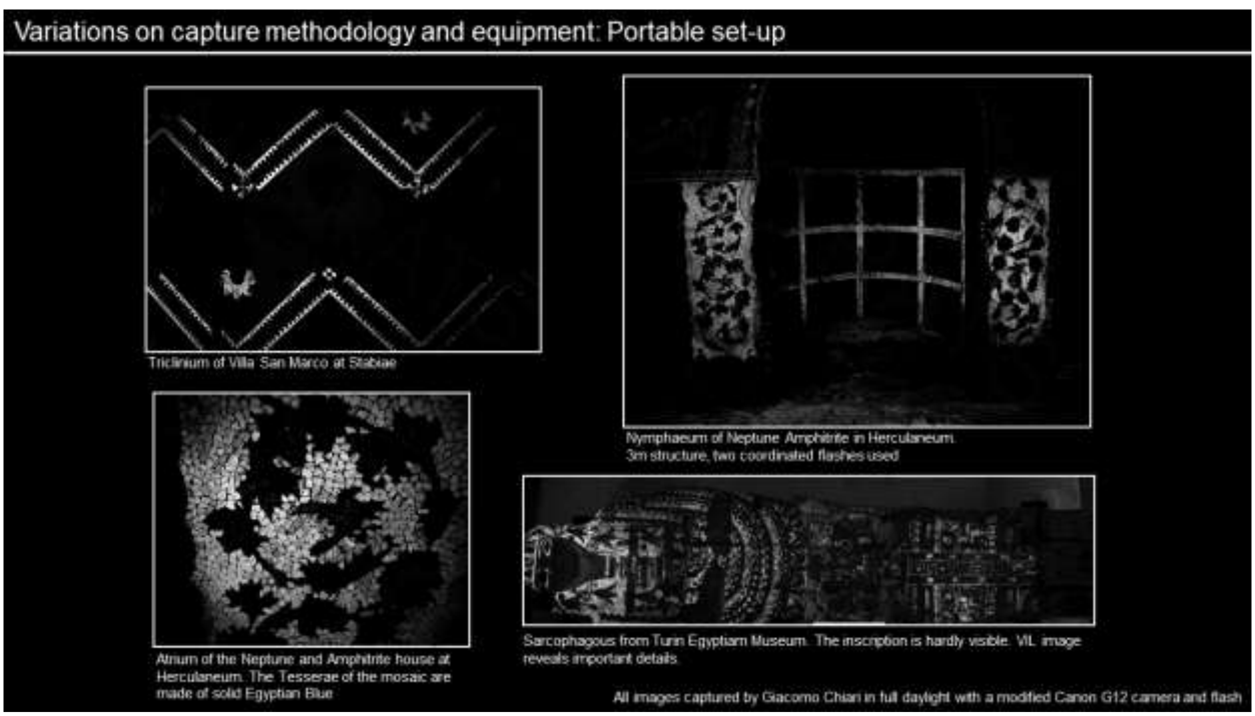


And here are just a couple of examples captured using this set-up at the Getty Villa Museum (visible images seen here).

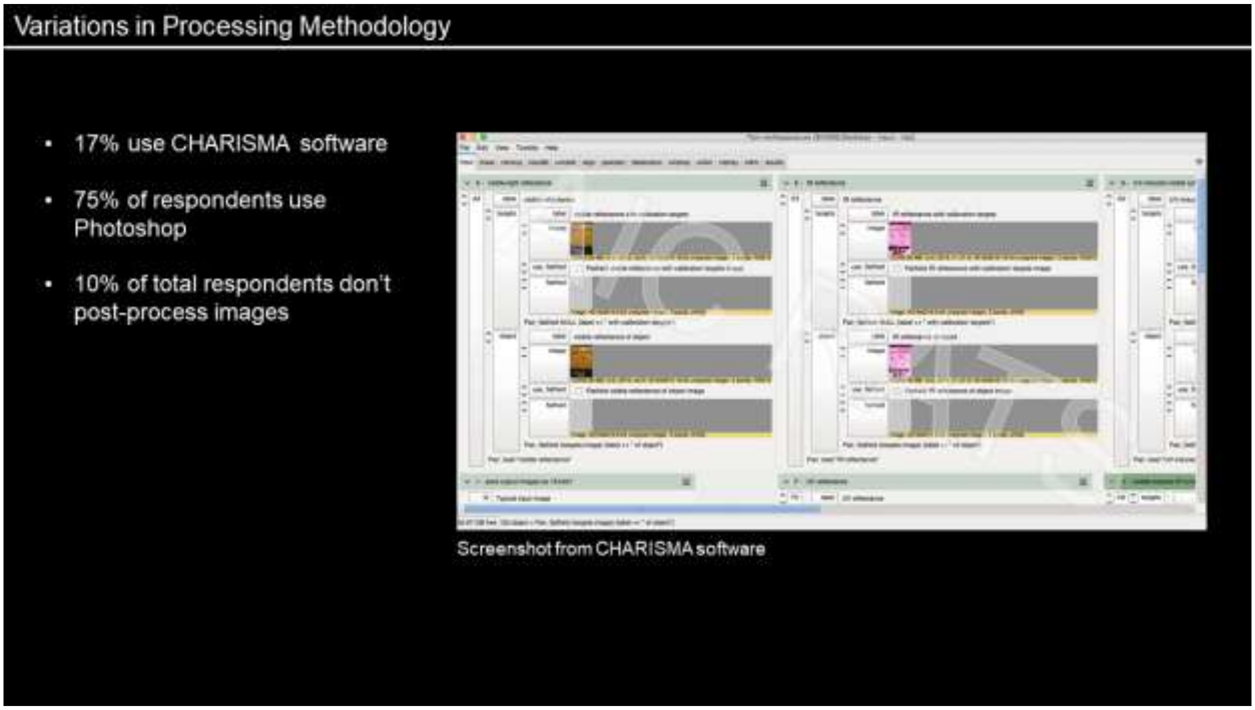


And here are just a couple of examples captured using this set-up at the Getty Villa Museum (VIL images seen here).

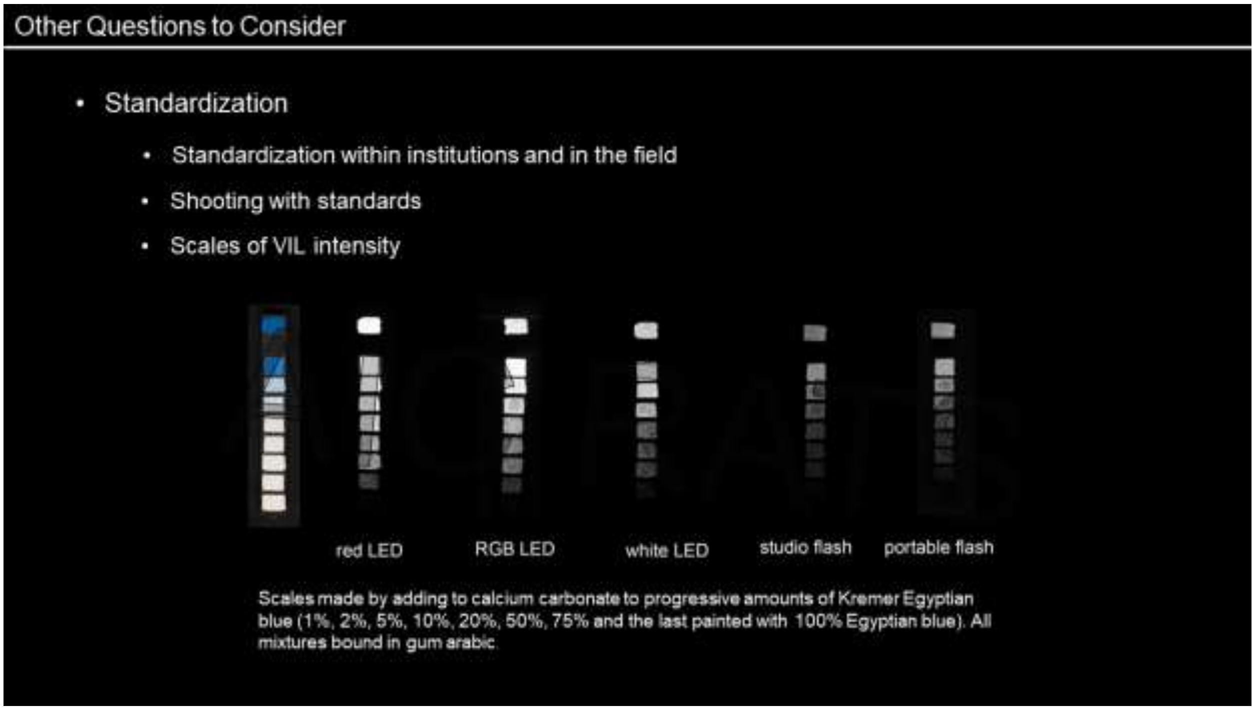
This set-up can be useful in field settings and with larger objects. All of these images were captured in daylight (visible images seen here).



This set-up can be useful in field settings and with larger objects. All of these images were captured in daylight (VIL images seen here).



Processing is just as critical as shooting. Most survey respondents are shooting in RAW and post-processing, which we feel is essential. Of those, nearly a quarter are using the open source software provided by the CHARISMA project, which aims to standardize VIL and other imaging methods by providing rigorous capture and processing guidelines. We use this methodology, and we strongly encourage other VIL practitioners to explore it. Photoshop is also commonly used. However you process your images, we really can't emphasize enough how important it is to be transparent in your processing methodology. This metadata is critical for the interpretation of scientific imaging.



In addition to the points already raised, there are other methodological questions.

First, its critical to establish a rigorous protocol in your own institution and be aware of what others are doing.

To that end, the use of standards is critical. We acknowledge that they can be costly, which can be a significant hurdle. In the absence of a standard in your shot, shooting and processing metadata becomes even more critical.

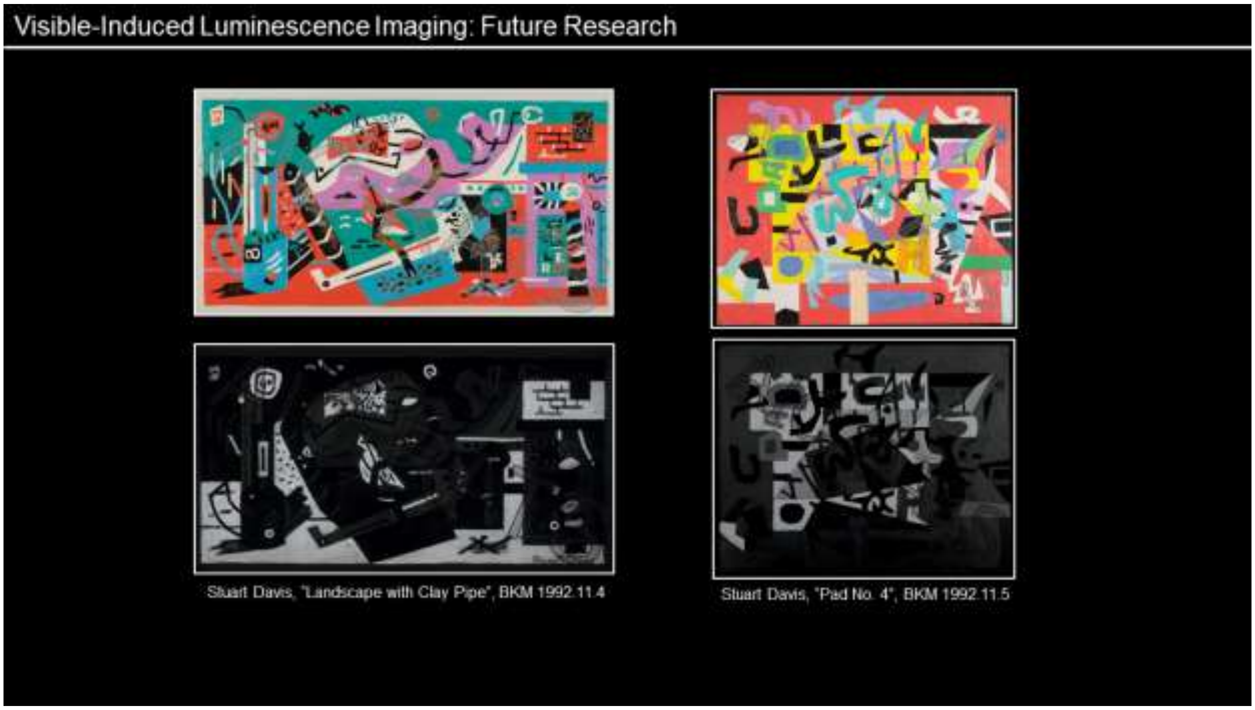
Third, is there any way to quantify the luminescent response of a surface? Our co-author Giacomo Chiari suggests that creating scales of VIL intensity using mixtures ranging from pure pigment to no pigment may allow for semi-quantification and might help to recognize minor effects of IR reflection. Here you can see a set of standards that we made imaged with a variety of light sources.

And this all comes back to questions of interpretation and sharing.

Individual VIL images are informative, but they become significantly more useful when combined with a suite of imaging types. When considered together, this bundle tells a more complete story about the object's surface.

If your images are properly registered you can cross-fade, which is great for highlighting the relationship between different optical behaviors. Here we can see that the VIL image helps us to not only map pigments when compared with the visible image, it can be compared with the UV to better understand restorations, and also with the x-radiograph to understand surface losses.

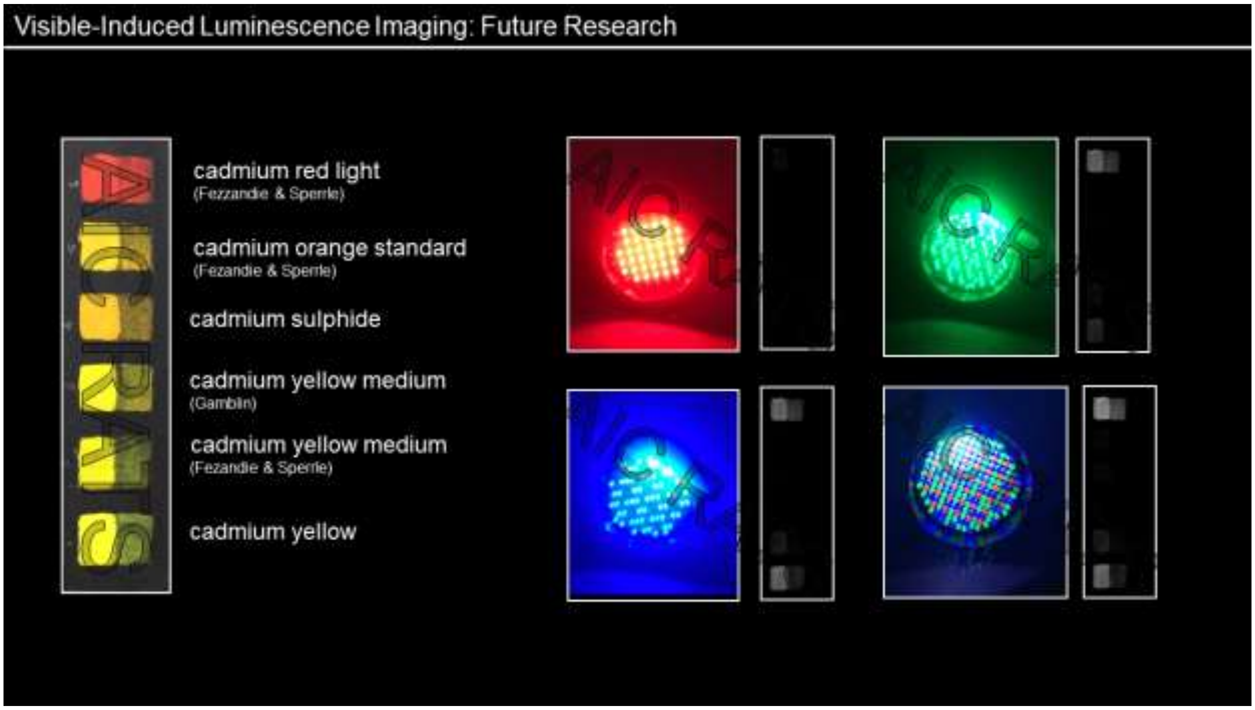
And, ultimately, where do we put this sort of data if we want to share it? Are there mechanisms for web-sharing that we can encourage our institutions to adopt?



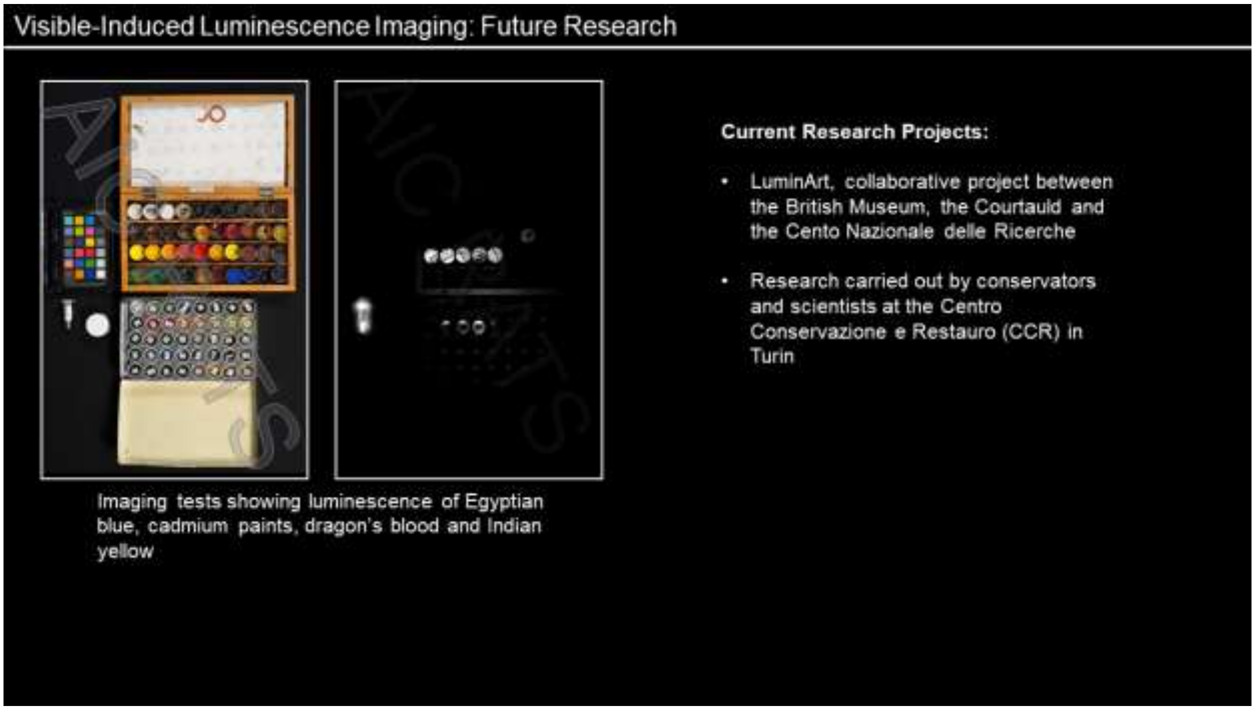
Another avenue of research that we and a number of colleagues are currently considering is the IR luminescence of pigments other than Egyptian blue.

Jessica Ford at the Brooklyn Museum has been looking at Stuart Davis pieces in our collection (she spoke yesterday on this project), and Davis seems to have utilized many cadmium-based pigments.

And here we have a nice map of some Cadmium reds on the left and yellows on the right. She has also identified cadmium pigments in mixtures, including in some of the greens.

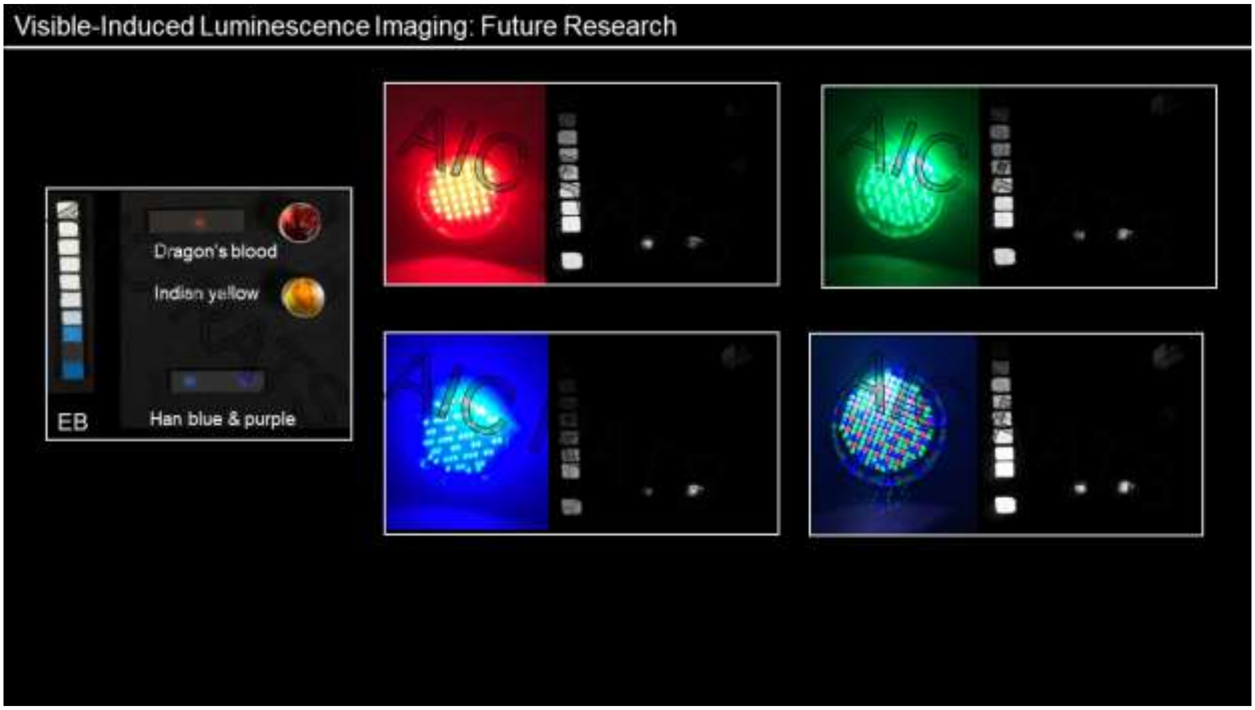


In our preliminary investigations, we have found that cadmium paints respond differently to various wavelengths. NYU IFA conservation student Hae Min Park has just completed a study on this topic as well, finding that both pigment and binder composition influence luminescence.



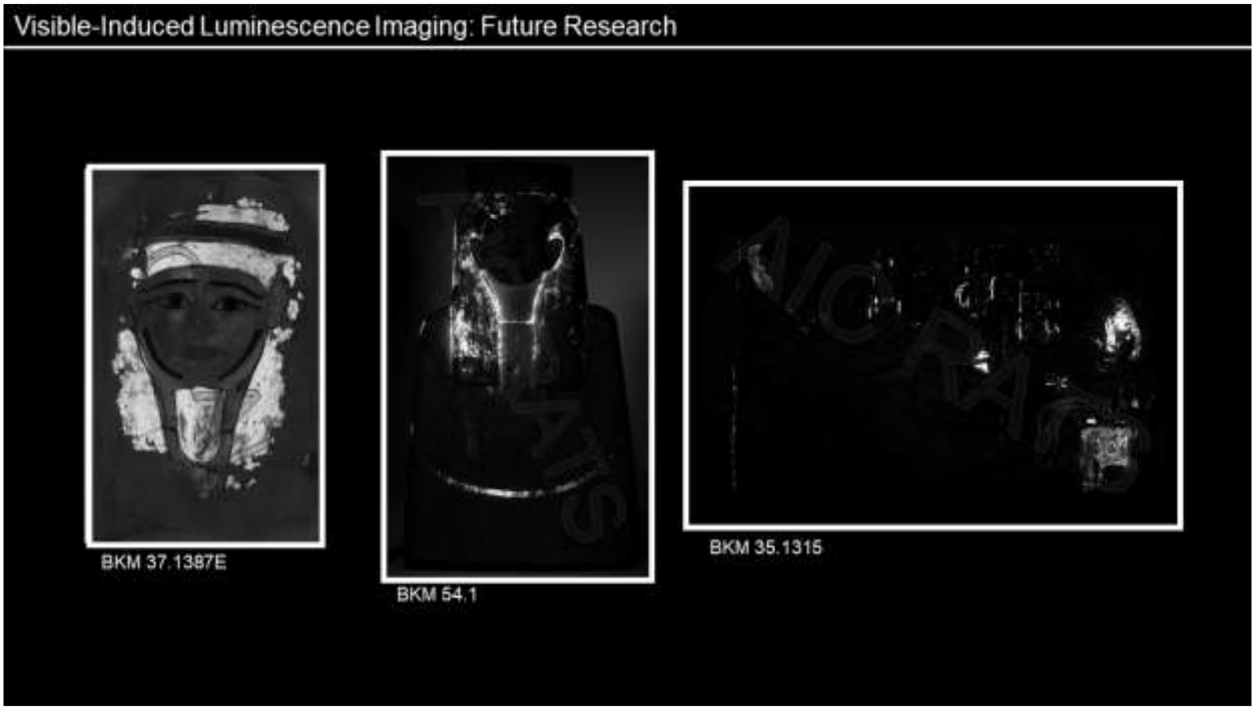
There are several other projects currently investigating luminescent materials, including Luminart and also the Centro Conservazione e Restauro in Turin.

Here are our preliminary investigations into the luminescence of paint sets in our lab. In addition to finding that the cadmium-based pigments luminesce differentially, we also found that dragon's blood and Indian yellow luminesce as well. Why is this the case? Are there other materials out there with similar properties?



Likewise, the particular wavelength range that excites these pigments bears further investigation.

As we have demonstrated, VIL is a powerful technique that can be readily adopted and adapted to address a variety of research questions. However, as with all analytical methods, the devil is in the details--and there are many factors to consider when designing an imaging protocol for your lab.



Clearly there is more work to be done, and we look forward to seeing what else is illuminated through future experimentation.

We would like to say thank you to all!

2016 – Research and Technical Studies and Photographic Materials Specialty Group Presentations

Analysis of Historical Tintype Plates: Materials, Methods, and Manufacturers

Corina E. Rogge

The tintype, a wet collodion photograph on a japanned metal support, became the most popular photographic technique in mid-19th century United States of America due to its durability, low cost, and the societal demands of the American civil war. Tintype plates consisting of a metal sheet with a protective varnish on the verso and the colored japanning layer on the recto were commercially available: at least 10 manufacturers are represented in trade advertisements of the time, and some offered plates with differently colored japanning layers (i.e. chocolate or black) or with different surface textures (glossy or eggshell). Despite the plenitude of manufacturers, and the production of millions of these cultural heritage objects, there is a dearth of information regarding what materials were actually used to create tintype plates. Two patents dating from 1856, the natal year of the process, list iron as the support material, and linseed oil, Japan varnish and colorants such as lamp-black, umber and asphaltum, as the constituents of the japanning layer. A third patent dating from 1870 cites the use of linseed oil and India red. However, japanning of tinware and leather was common and contemporary literature cites the use of shellac and other resins instead of (or in addition to) linseed oil, and so in an effort to maximize profit manufacturers may have used materials other than those cited in the patents. As part of an ongoing, comprehensive study on the material nature of tintypes, the metal supports and japanning layers of a study collection of 226 tintypes were analyzed by pyrolysis gas-chromatography (py-GC-MS), X-ray fluorescence spectroscopy (XRF), and microscopy. The predominant component of the japanning layers is drying oil, although some japanning layers also contain Pinaceae resin or shellac (64% and 3.5% of the collection, respectively). The primary material identified in the metal support is iron, although 22% of the collection also contain manganese. Dispersed sample microscopy revealed that the most common colorants in the japanning layer are iron oxide species and carbonaceous pigments, while py-GC-MS revealed only a limited use of asphaltum. The iron in the japanning layer may also have helped serve as a drier, as may the manganese and lead detected by XRF in 8% and 5% of the collection, respectively. Microscopy and cross-section analysis revealed that some japanning layers contain only a single homogenous layer, while others have been built up from multiple coats of material, with the lowest layer being the most highly pigmented. This densely pigmented layer likely corresponds to the 'black face coat' described in the sole historical essay describing plate manufacture. This first comprehensive analysis of tintype plates shows that the majority of plates differ from the patent literature in terms of the organic binders utilized. These results also reveal that the plate manufacturing process evolved through time and that different manufacturers used different formulations of materials to create their plates. Therefore, it may be possible to create 'profiles' for a given manufacturer- perhaps providing a date range for when a given plate was produced.

Characterizing RC Papers and Testing Adhesives Suitable for Their Hinging

Chris McGlinchey, Lee Ann Daffner, Roberta Piantavigna

For more than two decades, starting in the 1960s when they were first introduced, resin coated (RC) photographs have had a variety of flaws affecting the long term preservation of the different components. Today however, this paper type has fewer defects and has become widespread, particularly with the development of RC type papers for digital printing. The acquisition and display of these prints is now well established in museums that collect and exhibit contemporary art, however there remains a need for their safe and effective mounting. This research focusses on 8 name brand RC papers that are currently available in the US and one historic paper by Kodak from ca. 1978. ATR-FTIR data was collected from the recto using both diamond and germanium crystals to sample the coating at different depths. Results indicate the historic paper is coated with unmodified polyethylene while the modern papers range from the same non-polar polyethylene resin to more polar surfaces, likely via surface oxidization. A polar surface is intentional and designed primarily to improve the wetting and bonding of ink onto the surface but will also influence a tape's ability to adhere. In this regard, tapes are being studied for shear and peel strength using conditions that approximate the load of the largest prints that might be exhibited. The shear mode findings are good for most of the adhesives tested, including wheat starch paste and methyl cellulose, but in peel mode - the Achilles' heel for thermoplastic adhesives - tapes fail more rapidly or show signs of creep. This suggests that if the latter mode can be avoided in the hinge design, adhesives that are more easily reversible on demand could be utilized for any of the papers tested. In addition to ATR-FTIR studies, characterization of versos by tactile feel, optical surface roughness, and simplified aqueous contact angle measurements will be discussed in the context of adhesion.

Identification of Chromogenic Colour Photographic Prints Brand by Spectral and Statistical Analysis

Christine Andraud

Recent scientific studies have been devoted to the identification and characterisation of monochrome photographic processes starting from the earliest time of the history of photography since they were the most significant part of the collections and the main source of questions. However since the turn of the century similar concerns addressed to color photographs that are increasing in the collections, especially question of brand identification. Actually, being able to identify a colour process, a brand or even a period of printing may inform us about the history of the artefact and also its sensitivity to the environment. It is well known that some brands and production times correspond to different thermal and light ageing behaviours. For instance some manufacturers have improved chromogenic colour prints stability in the 1980's. Identifying a print manufacturer may help to define an exhibition strategy by referring to existing - or future - stability data. The name of the manufacturer is often printed on the back of colour prints with sometimes the year of production, however date or names are sometimes lacking and many prints in museums are permanently mounted on a polymer or aluminium support without access to the information written on the back and no proper documentation neither. The aim of this study is to investigate the possibility of distinguishing materials from various manufacturers and periods by comparing their spectral signatures using non-invasive fibre optical reflectance spectroscopy (FORS) in the near infrared range. First, spectra have been collected on a limited number of chromogenic colour photographs to create a database. Then we evaluated the rate of success in attributing a brand to a print by comparing it to known prints from the database by applying different statistical procedures.

Investigation and Optimization of Electrochemical Treatment for Daguerreotypes

Elyse Canosa

Extended Abstract

Daguerreotypes are some of the most cherished and perplexing photographic objects. Prior attempts to remove daguerreotype deterioration products and restore the original image have proven unpredictable and even harmful to the object. A form of electrochemical cleaning, potentiostatic cathodic polarization, was proposed to remove daguerreotype deterioration products without altering the original materials or image structure of the photograph. This project focuses on optimizing the electrochemical cleaning process for removing silver sulfide corrosion on daguerreotypes. The effects of treatment were characterized through scanning electron microscopy - energy dispersive x-ray spectroscopy (SEM-EDS), atomic force microscopy (AFM), Raman spectroscopy, and x-ray photoelectron spectroscopy (XPS). The information from this study will help photograph conservators to create informed, scientifically supported decisions concerning daguerreotype treatment.

Unlike many photographic materials, daguerreotypes were not created on a paper base. Rather, they are made entirely of metal and the images are composed of very small silver-mercury amalgam particles that rest on a substrate of highly polished silver. This provides daguerreotype plates with both extremely high image resolution and a reflective surface. Corrosion products on daguerreotypes mainly take the form of silver sulfide, resulting from interactions between silver and hydrogen sulfide in the environment. Unfortunately, all prior attempts to remove corrosion have harmed daguerreotype plates: silver dips left residual chemicals on the objects, inducing new forms of corrosion; mechanical abrasion scratched the highly reflective surface; and earlier forms of electrochemical cleaning were unpredictable and caused plate delamination. A more recent study proposed a different form of electrochemical cleaning for daguerreotype restoration.[1] This technique involved changing the electrolyte solution and the counter electrode material, while adding a reference electrode (earlier methods did not include a reference electrode). The proposed technique also suggested to apply only a steady cathodic (i.e. negative) voltage to the daguerreotype, while the earlier electrochemical technique called for oscillation between anodic (i.e. positive) and cathodic voltages. By using a steady cathodic voltage, the daguerreotype does not run the risk of corroding in the electrolyte solution. The proposed method was in need of further characterization to understand its effects. This project provides greater comprehension of the cathodic-polarization electrochemical cleaning process when applied to daguerreotype restoration, and does so through optimizing treatment while analyzing both modern coupons and 19th century daguerreotypes.

Modern daguerreotype coupons (2.4 cm x 3.1 cm) were obtained from a contemporary daguerreotypist. All had similar, uniform image densities. These coupons were characterized as-received using SEM-EDS, AFM, XPS, and Raman spectroscopy. The coupons were then placed in a desiccator, suspended over a solution of potassium polysulfide to produce silver sulfide corrosion products. The coupons were first used to optimize the cathodic cleaning process, performed through potentiodynamic polarization scans in an electrochemical cell. The cell contained a 0.1 M sodium nitrate electrolyte, platinum counter electrode, and mercury-mercurous sulfate reference electrode (MSE). The top surface of the coupons were isolated in order to reduce interactions with the copper substrate. During the scan, a series of increasingly negative voltages were applied to the samples, beginning just below the open circuit potential. Scans began at approximately -0.3 V (vs. MSE) and continued to approximately -1.8 V (vs. MSE). The fastest rate of silver sulfide reduction on the daguerreotype surface occurred at -1.3 V (vs. MSE), thus indicating the optimum voltage for cathodic electrochemical cleaning. This voltage was therefore used to clean all contemporary and historical daguerreotypes in the remainder of the study.

To observe the effects of treatment, corroded modern coupons were characterized before and after electrochemical cleaning. A steady voltage of -1.3 V (vs. MSE) was applied to all coupons for a total of 5 minutes. At 5 minutes, the current had already reached a low, steady state value, indicating low reaction rates. SEM-EDS, Raman spectroscopy, and XPS all showed the formation of silver sulfide on the daguerreotype surface after corrosion. The techniques also revealed that while the corrosion layer had been significantly reduced as the result of cleaning, some residual silver sulfide remained after 5 minutes of treatment. The same exact locations were imaged in SEM before and after treatment, and the micrographs did not reveal any changes to the shape, size, or structure of the daguerreotype image particles. Additionally, AFM surface measurements indicated no significant changes in roughness on the nanoscale as the result of corrosion and electrochemical cleaning. Raman spectroscopy and XPS were also used to look for the presence of any surface deposits resulting from cleaning, particularly nitrates from the electrolyte, but no indications of deposits were found.

The effects of cleaning were then observed on three different historical daguerreotypes. After treatment, SEM showed that small, irregularly shaped particles were removed from the surface of one daguerreotype, while larger rounded particles remained intact. It is theorized that the small, irregular features were silver sulfide agglomerates and not image particles as EDS did not show the presence of mercury on these particular shapes. Similar to the contemporary coupons, Raman spectroscopy and XPS all showed that silver sulfide was reduced, but not completely removed from the surface after treatment. Additionally, nitrate deposits were not indicated in the spectra. AFM measurements showed no significant changes in roughness as the result of cleaning.

While the electrochemical cleaning process outlined and characterized in this study greatly reduces the risks associated with prior restoration techniques, it is still completely irreversible in nature. It should also be noted that corrosion removal exposes a newly reactive surface, re-initiating the atmospheric sulfidation process. If daguerreotypes are stored in low temperature and low humidity facilities with limited light exposure and air filtration after cleaning, then the process of tarnishing will be extremely slow. Future investigations could include analyzing naturally aged daguerreotypes previously subjected to the electrochemical treatment process and assessing their condition after several years or decades. Such analysis would indicate if the treatment is appropriate for the long-term preservation of daguerreotypes.

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Photography, Continuity and Change: Impact on the Conservation Field

Bertrand Lavedrine

View from afar, the history of photography seems to be a long quiet river (to paraphrase the title of a French movie from the 1980s). Technically, each decade and each century has brought its tribute of innovations and discoveries through a linear evolution process. Like in the 19th and 20th centuries, we are still producing photographs with our cameras, and trying to keep them. It is true that photography today inherits from all the technical and artistic contributions from the past. However, the introduction of digital technologies has created discontinuities that are not always clearly tangible. The first one is the use, for a sake of convenience, of the traditional terminology such as «photograph» for naming digital images. This may create the feeling that we are still in the same domain, however, technically, we have moved in another dimension that has impacted our private, public, and professional areas. This paper will address, through a few examples, some changes that digital imaging has induced on the way we are assessing or preserving images and on the scientific researches in the conservation field.

Surface Roughness, Appearance, and Identification of AGFA-Gevaert Photograph Samples

William Wei, Sanneke Stigter

The age of digital imaging is rapidly pushing traditional photographic methods into the background. Furthermore, the replacement of discolored analogue photographic prints has become museum display policy, as it is seen as a solution in conservation, and is sometimes promoted by artists. There is therefore an urgent need for methods to characterize photographic materials while they are still available and/or in relatively good condition. Surface properties are some of the most important because they determine the appearance and perception of photographs as works of art These properties are also valuable for identification and authentication purposes. In particular, the roughness of the surface of a photograph determines the glossiness, but also affects the perception of color. Moreover, a surface's physical character situates the print in time. The photographs materials collection developed by P. Messier, and associated raking light methods for surface texture characterization are a good first step in classifying and identifying photographic materials based on surface roughness. However, in many cases, more direct techniques for measuring surface roughness are required, especially when it comes to assessing the effects of surface treatments. These need to be related to the actual appearance and perception of the materials to allow for better identification, or assessing changes in appearance due to treatments or aging. Over the past 25 years, white-light or laser confocal profilometry has become a standard technique for measuring roughness in many branches of industry. Besides being a non-contact method, the technique measures roughness directly with a resolution down to tens of nanometers, much better than any current optical method. Roughness can be characterized by the calculation of industrial standard roughness values, for example, average roughness, Ra or root-mean-square roughness, Rq. 3D visualization techniques can be used to characterize changes in surface roughness due to treatments or, more generally, the identification of photograph types. Currently, a study is being conducted by the University of Amsterdam and the Cultural Heritage Agency of the Netherlands on the relationship between surface properties and the appearance of photographic materials. The surface roughness of samples from an Agfa-Gevaert photographic sample book (1972 or 1973) was measured using a NanoFocus µSurf confocal white light profilometer, with a spatial resolution of less than 1 micrometer and a height/roughness resolution of 60 nanometers. The results are being related to the perception of a number of conservators and other museum professionals who were asked to judge the appearance of the samples. The results of this research thus far have shown that, when identifying photographic materials or making judgments about their condition, it is important that one considers both the "objective" values of surface properties such as roughness in relation to time and possibilities of the photographic industry, and the "subjective" interpretation of the observer, influenced by interest, cultural background, and time.

Full Paper:

Wei, W., and Stigter, S. 2017. Surface Roughness, Appearance and Identificaion of AGFA-Gevaert Photograph Samples. *Topics in Photographic Preservation* 17: 11-24.

2017 – Research and Technical Studies Specialty Group Presentations

Conservation Science 2.0: The Northwestern University/Art Institute of Chicago Center for Scientific Studies in the Arts

Francesca Casadio, Marc Sebastian Walton, Monica Olvera de la Cruz, Emeline Pouyet, Johanna Salvant, Ken Sutherland

The Northwestern University/Art Institute of Chicago Center for Scientific Studies in the Arts (NU-ACCESS) was founded with a generous grant of $2,5M from the Andrew W. Mellon Foundation as a collaborative endeavor in conservation science that pursues objects-based and objects-inspired scientific research to advance the role of science within art history, curatorial scholarship, archaeology, and conservation. By leveraging resources at the Art Institute (AIC) and materials-related departments at Northwestern University (NU) the center, the first of its kind, is developing, harvesting and adapting innovations in other fields to advance our capabilities of studying, preserving and treating art. Within the Northwestern campus, it is serving as a catalyst to inspire and direct new cutting edge research in academia focused on cultural heritage, with accomplishments in analytical science, modeling, visualization, data fusion and data processing as demonstrated by over 40 peer reviewed publications to date. The Center also brings scientific equipment and expertise to collections that have no such talent in house (most recently, for example, the Guggenheim museum in New York, the Georgia O'Keeffe museum in Santa Fe, and the Musèe National Picasso in Paris, France). This research and education initiative also provides enhanced training opportunities for participants through involvement in university-museum multidisciplinary programs, early career internships, postdoctoral fellowships and visiting scholars' opportunities. Now in its fourth year of operation, the center is internationally recognized as a model of interdisciplinary scientific research in the arts. Since its creation the Center has focused on a broad variety of projects on materials ranging from archaeological glass and paintings to modern bronzes and artworks pursuing objectives as diverse as collecting materials evidence for dating, advancing knowledge for technical art history, enhancing conservation and exhibitions and developing new technologies. To date, more than fifty proposals have been submitted from all around the world, demonstrating the great need of such a resource for museums that have the intellectual curiosity but not the scientific expertise in house. In this talk we will provide select examples of NU-ACCESS projects to illustrate the center's role as a sustainable model for integrating scientific investigation into the next generation museum practice.

Conservation Science in Early Twentieth Century India: Dr. S. Paramasivan and the Chemical Conservation Laboratory at the Madras Government Museum

Sanchita Balachandran

Nearly a century after conservation science laboratories developed in museums in Berlin, London, Paris, Cambridge and New York, a 2015 special supplement of Studies in Conservation (SIC) sought to clarify the professional and scholarly commitments of the field of conservation science, and to re-define the competencies and role of the conservation scientist in the twenty first century. Of new import in 2015 was the need for the practice of conservation scientists to be interdisciplinary, community-engaged, and strategic. This paper reclaims the place of a pioneer of conservation science, Dr. Subramahnya Paramasivan (1903-1987), who as the first "archaeological chemist" at the Chemical Conservation Laboratory (CCL) at the Madras Government Museum (MGM), India, forged a new path in the study and preservation of Indian cultural heritage that remains relevant and revolutionary, and in keeping with the aspirations of the 2015 SIC publication. At the helm of the CCL from 1930 to 1946, Paramasivan's tenure was marked by a desire for understanding the physical and chemical factors that affect an object's condition and long-term preservation in a holistic way; a dogged pursuit of treatments best suited to the particular conditions not only of the objects in his care, but also the cultural and social context in which he worked; and an insistence on collaborative and interdisciplinary research to best understand a collection's preservation needs as well as its scholarly interpretation. Also significant was Paramasivan's scholarly engagement with scientists working in the field, in particular his correspondence and exchange of ideas and techniques with Rutherford Gettens. Drawing on archival documents, publications, oral histories and an extended residency at the site of the current CCL, this paper sheds light on Paramasivan's ability to negotiate and integrate scientific, cultural, political and religious demands in the preservation of museum objects. The paper further broadens the narrative of the history of conservation science, providing new evidence for the approaches of early scholars working in the field beyond Europe and North America.

Early Intervention for At-Risk 21st Century Fugitive Media

Fenella France, Chris Bolser, Meghan A. Wilson

Effectively controlling the environment to reduce the need for invasive treatments is the goal for all heritage professionals. While significant attention is directed to historic materials, we all too often fail to recognize the more modern at-risk challenges in our collections. These risks can include both the impact of various storage environment parameters as well as challenges of display. Previous research has shown that significant changes in chemical and physical properties often occur early in the lifetime of historic and modern objects for a range of materials with the rate of change decreasing over time. This was true for the Star-Spangled Banner, with the interaction between keratin (wool) and dyes showing the photo-protective effect of some of the dyes on the chemical and mechanical degradation. One additional challenge is that most collections have experienced use, display or natural aging before they enter controlled collection storage environments. Research to determine environmental impact on modern felt-tip pens used on drawings in the Herb Block Collection at the Library of Congress led to exploration of light, dark and temperature effects, since the collection materials seemed to be both photo and thermally unstable. Curatorial staff observed fading in collection items that had never been exhibited or exposed to light. To assess these chemical changes, reference pen samples that replicated those used in these 21st century cartoon drawings were created and the media separated by thin layer chromatography (TLC) into its component dyes. This was to assess the relative light sensitivity of each of the dye components to identify what pens put specific drawings at greater risk. These penstix, sharpie, rub-a-dub and other felt-tip media samples were also drawn out on a range of substrates to assess the interaction between substrate and media. Samples were then placed in controlled light, dark and cold storage environments for successive periods of time and examined progressively over a period of 18 months. At the same time collection items containing the same media were kept in dark and cold storage environments. Both the TLC reference samples and collection items were examined non-invasively with spectral imaging to track any changes over time in response of the media to different natural aging storage environments. Media samples on various substrates were exposed to accelerated aging environments – light (with/ without ultraviolet) and dark, both with controlled temperature and relative humidity. Additional examinations were made using a microfade-tester (MFT) to determine a relative light sensitivity between the various media. Analysis of changes in substrate materials were also undertaken. Results indicated significant differences over time in sensitivity to light and dark natural environments for the fugitive media, with cold storage of reference samples indicating a protective effect. Collection items did not show the same definitive trend, probably since they had already undergone a combination of light, dark and natural aging. This research has positive implications for modern collections of fugitive media coming into heritage institution collections, since early intervention and storage in cool and cold environments will retard media fading, color change and loss.

Minimally Invasive Sampling for the Analysis of Proteins from Solids and Surfaces

Dan Kirby

Proteins from a variety of sources, such egg, milk, hide and fish, are ubiquitous components of artworks and cultural objects. It has long been recognized that detecting the presence of and determining the nature of proteins is an important part of conservation. Knowing the materials used gives important insights into the choices and intentions of the artist; knowing the materials can aid in determining authenticity and guide future generations in understanding and accurately recreating the culture of their ancestors; knowing the materials is essential toward directing conservation, storage and display. Historically, the detection and identification of proteins in artworks has been accomplished by a variety of methods including amino acid analysis (AAA), FTIR, Raman, immunological methods (ELISA), GC, GCMS. PyGC, and HPLC. Each method has its strengths and weaknesses. For example, FTIR and Raman may be the least invasive methods but in most cases can offer little more than verification of the presence of protein and perhaps broadly classify its origin. AAA requires relatively large samples but can determine protein presence and generally discriminate among broad classes of proteins found in artworks. ELISA offers high sensitivity and small sample requirements but can suffer from the lack of relevant antibodies. The relatively recent migration of LCMSMS and PMF into the conservation laboratory offers enhanced sensitivity and specificity and significantly advances the conservator's ability to identify proteins with high sensitivity and specificity. Despite increased levels of sensitivity of newer methods, protein determination still requires that samples be taken from the object for analysis. Although some artworks offer acceptable "sampling opportunities," such as paint on a folded canvas edge or areas of prior damage, in many cases such opportunities are absent, and the conservator must decide whether the potential gain in information outweighs the need to alter the object or painting, however slightly. This presentation will discuss two minimally invasive methods developed for sampling solids and surfaces to obtain material sufficient for subsequent protein analysis by PMF or LCMSMS. The first method, the use of 2–3 mm3 polymer eraser cubes, is an extension of the method (triboelectric extraction) described by Fiddyment, et al.1 for noninvasive sampling of velum. This adaption of that method is best suited for sampling friable surfaces and coatings thereon, where minute amounts of surface and/or coating material can be abraded loose and adhered electrostatically to the cube. The second method utilizes polishing films of fine alumina or diamond particles and is best suited for hard surfaces, such as ivory, bone, paint and photographs, which might not be sufficiently abraded by the eraser. Although technically invasive, both methods offer an option for obtaining samples with nearly unnoticeable effect on the surface. In each case, the sampling device, eraser cube or polishing film, is placed directly into the digestion buffer for subsequent enzymatic cleavage for protein analysis by PMF or LCMSMS. Examples of the use of both methods will be shown for analyzing samples from parchment, ivory, bone, hide, photo prints and painted surfaces.

1. www.pnas.org/cgi/doi/10.1073/pnas.1512264112

Revealing the Text and Folds in 17th-Century Locked Letters

Jana Dambrogio, Graham Davis, David Mills

The international and interdisciplinary team of researchers on the Signed, Sealed, & Undelivered Project recently rediscovered early modern letters including 600 that were never opened. The team is collaborating with the Queen Mary, University of London's Institute of Dentistry to apply their Computed Microtomography (CT Scanning) imaging technology to capture complex folding patterns and textual information hidden away without physically tearing open the letters. The project explores a 17th-century trunk held by the Museum voor Communicatie in The Hague. The trunk is filled with an extraordinary archive: 2,600 letters, which were never delivered. The trunk's contents remained virtually untouched by historians until recently rediscovered. They show history preserved at the time of the "Glorious Revolution," capturing voices which might have never have been heard otherwise. The letters are examples of a technique called "letterlocking" — folding and securing an epistolary writing substrate to function as its own envelope. Part of the effort of the team includes preserving, imaging, transcribing, and identifying letterlocking formats to reveal the chest's secrets for the first time. Micro Computed Microtomography (XMT)[Elliott 1982] is an established technique for the non-invasive, non-destructive 3-D imaging. It is gaining traction in the conservation world for imaging items to gauge their level of damage prior to conservation work, or digitizing objects too fragile to be handled. The high spatial and contrast resolution of the XMT scanners developed at QMUL allows the direct imaging of inks [Mills 2014] and hence, writing inside the Brienne letters. The 3-D volumetric data produced by the scanners also allows investigation of the letterlocking techniques employed by each letter. We present initial results from the first batch of ten letters scanned in 2016. Elliott, J. C. and Dover, S. D. (1982), X-ray microtomography. Journal of Microscopy, 126: 211–213. doi:10.1111/j.1365-2818.1982.tb00376.x Mills D, Curtis A, Davis G.R, Rosin P. (2014) Apocalypto - Reveling the Bressingham Roll, Journal of Paper Conservation, Vol 15 (2014), no 3, p 14-19

Sculpting in Color: The Innovative Glazes of the della Robbias and Followers in Renaissance Florence

Richard Newman, Abigail Hykin

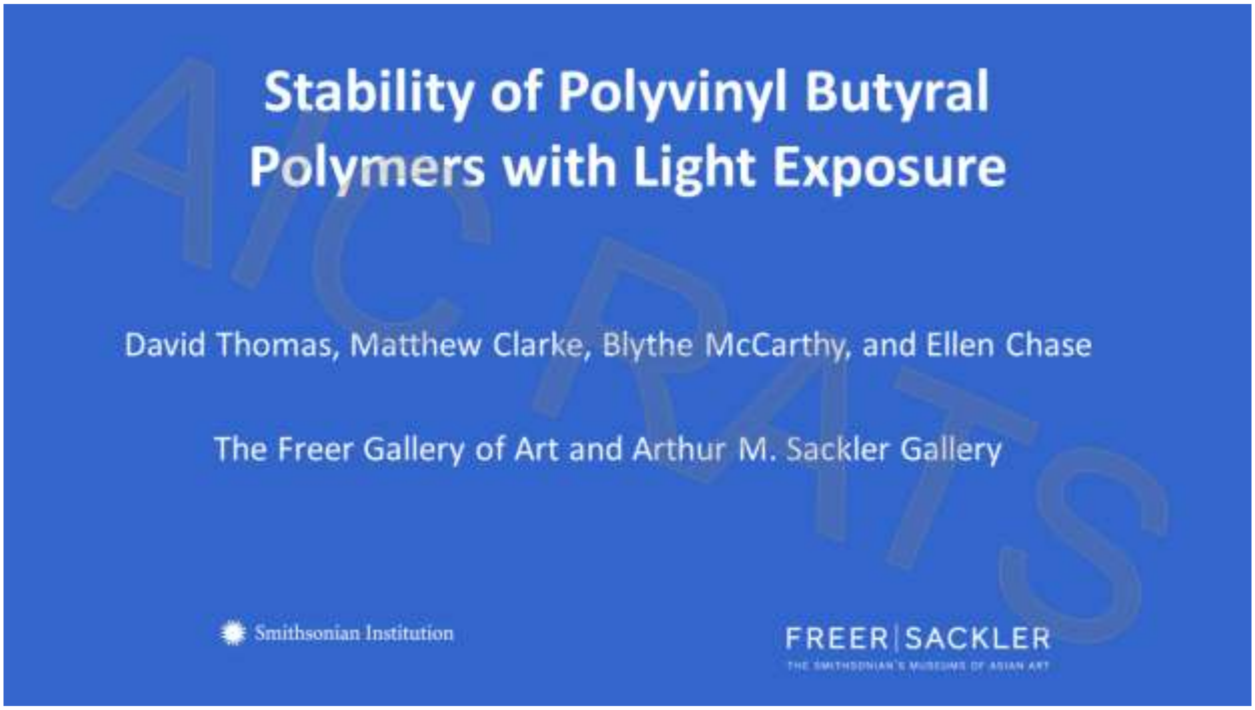
The Florentine sculptor Luca della Robbia began to develop and perfect an innovative glazing technique for terracotta sculpture around the middle of the 15th century. Building on these experiments, the della Robbia family workshop produced glazed terracotta reliefs over the next century that were highly popular and widely admired. A rival workshop was established by Benedetto Buglioni, and some other artists also produced sculptures that featured bright, opaque glazes inspired by the della Robbias. In association with two special exhibitions at the Museum of Fine Arts, Boston, including the recent "Della Robbia: Sculpting with Color in Renaissance Florence" (August 9-December 4, 2016), the glazes from nearly two dozen sculptures by the della Robbias and followers have been studied over the past ten years. An early 20th century reproduction by the Florentine Catagalli workshop has also been studied. Although the majority of the studied objects are from the Museum of Fine Arts, Boston, several are from other American collections.The research has involved extensive collaboration with the MFA's curator of European decorative arts and conservators at the MFA and other institutions. Sculptures from all generations within the della Robbia workshop have been included as well as several from the Buglioni workshop. This research, mainly carried out by examination of cross sections by scanning electron microscopy/energy-dispersive X-ray spectrometry (SEM/EDS), adds to the previously-published body of work by scientists in France and Italy. The European researchers have studied ceramic bodies and glazes, utilizing various analytical techniques. The work carried out at the MFA combined with the European research provides many insights into the nature of the della Robbias' innovations and the variations with their workshop; the research also makes it possible to examine relationships between the work of the della Robbias and that of other artists inspired by them. The della Robbias' techniques did not involve new materials, as their glazes have many affinities with those of contemporary majolica objects, but instead represent a focus on certain combinations of the raw materials that were carefully developed to produce particularly bold opaque colors made to carefully fit the underlying ceramic bodies on which they applied, so firing often produced no significant cracking in the glazes. This paper briefly summarizes previously published work and highlights findings from the unpublished work at the Museum of Fine Arts, Boston. The paper provides scientific analysis on objects that are the subject of several treatment-related papers submitted to the Objects Specialty Group..

Stability of Polyvinyl Butyral Polymers with Light Exposure

David Thomas, Matthew L. Clarke, Blythe McCarthy, Ellen Chase

Abstract

The need to consolidate a painted gypsum plaster surface on a Kizil wall painting fragment presented distinct challenges. The gypsum finishing layer on a mud and straw support is matte in appearance, and had been previously consolidated with a non-aqueous hydrophobic material. This earlier treatment resulted in the inability to use an aqueous material such as funori, and spurred a search for alternate solvent-based consolidants. Polyvinyl butyral polymers (PVBs), often used on many organic materials and as a consolidant for archaeological wood and bone, were recommended as a possible alternative, however, there were concerns regarding the long term ageing and stability of the material. As a result, a research project was undertaken to build on the previous work by Feller and others. Cast films of Butvar B-76, Butvar B-98, Mowital B30H and Acryloid B-72 (the widely used acrylic copolymer) were investigated before, during and after exposure to ultraviolet light. Additional samples underwent accelerated aging in a Weather-ometer that simulated indirect daylight filtered through pane glass. Property changes were assessed using fiber optic Fourier Transform Infrared spectroscopy (FTIR), color measurements, solubility tests and visual examination. UV and simulated daylight samples exhibited similar changes. PVB samples yellowed slightly with exposure, showed an increase in oxidation concurrent with film weight loss, and remained removable with ethanol suggesting lack of cross-linking. The degradation rate depended on the particular PVB formulation, though the exact cause was not determined. To test the effectiveness of the materials in a situation more analogous to the wall paintings that initiated the project, samples of plaster were consolidated with each of the resins being studied. These also were exposed to UV light and measurements were carried out similarly to those on the films. Due to penetration into the plaster and shielding effects of this material, discoloration was not observed after UV exposure and the films remain readily removable by mild organic solvents such as ethanol.



Freer & Sackler Galleries, the Asian art museums of the Smithsonian

The **Sackler has sixteen wall fragments on long term loan from the Smithsonian American Art Museum,** Gellatly collection

They originate from the **Kizil Cave Complex** in Western China near the Mogao caves of Dunhuang

Material identification of paintings from the complex was done as early as 1938 by Gettens, and more recently by Zuixiong in 2010

Paintings are an earth substrate mixed with organic fibers on rock surface of caves

Substrate is in two layers: coarse underlayer of clay mixed with sand and straw, and a finer layer of fine clay and sand mixed with hemp or in some cases wool

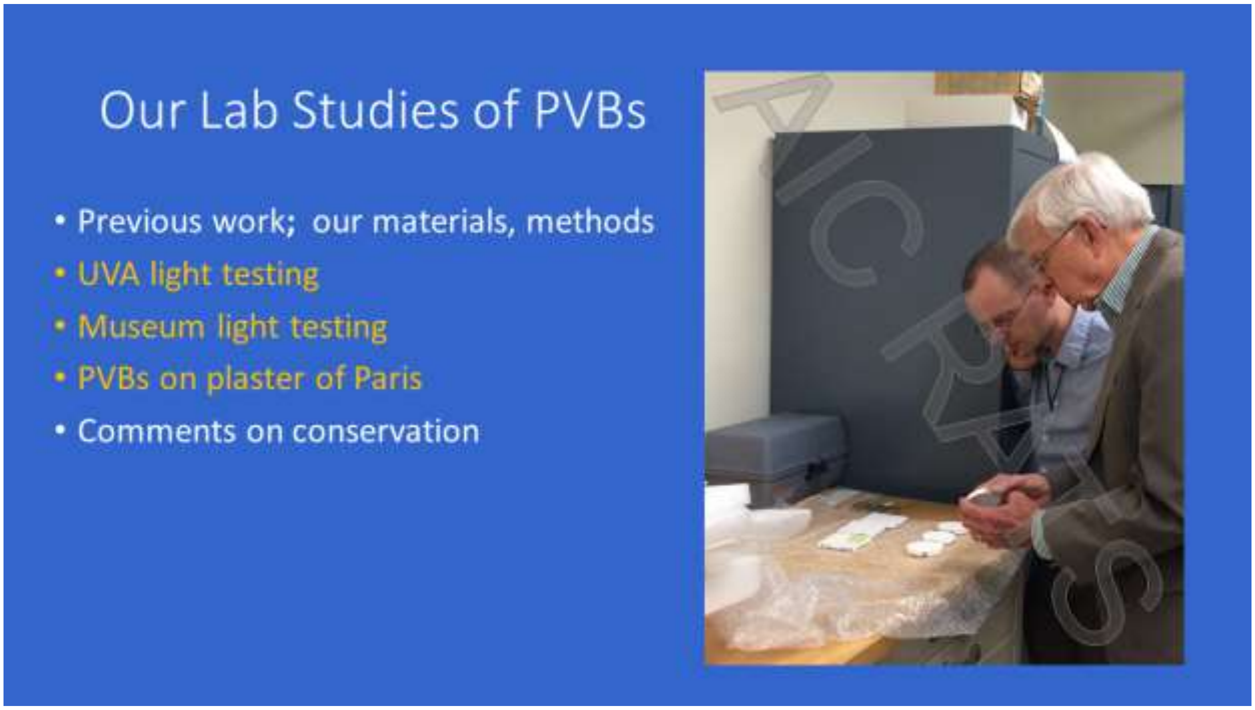
Gypsum ground layer and mineral pigment/organic binder paint layer

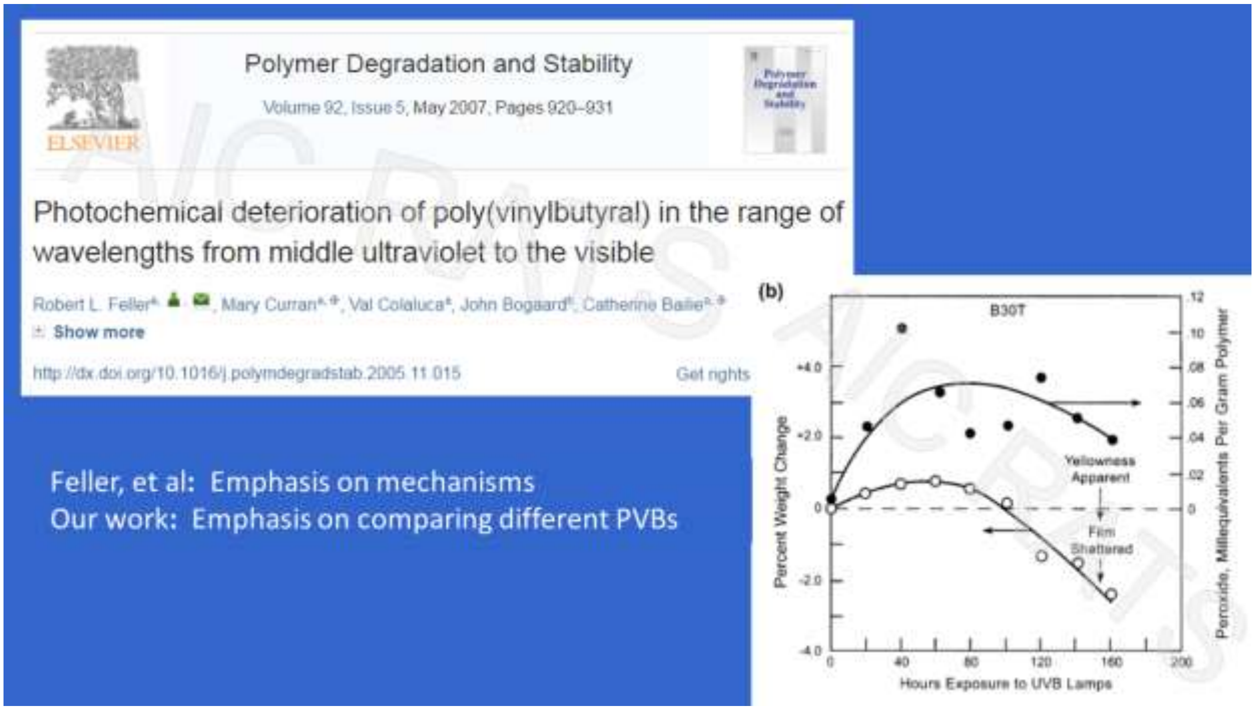
Layers and materials result in a vulnerable structure and surface

The fragments currently in the Sackler were consolidated prior to coming to the museum with an unknown hydrophobic adhesive that is soluble in acetone. Although some areas are shiny from heavy consolidation, the overall appearance of the paintings is matte. Despite this consolidation, some lifting was noted to areas of the paint layer. Where not consolidated, the wall paintings were found to be somewhat sensitive to water, so a using a matte, solvent-based adhesive was preferred. PVB was recommended as a possible material to use, however, previous reports of PVBs yellowing over time raised some concerns, since the areas to be consolidated were in light colored sections of paint.

PVB's have been used most commonly for consolidating archaeological wood and bone, however, they also have been used for both consolidation and adhesion of a number of other organics. They have started being used for inorganics as well, such as an adhesive for plaster, a surface consolidant for ceramics, and as an adhesive for ceramics in hot climates, where the glass transition temperature of B-72 has been found to be too low.

Any previously reported yellowing of PVB would not be as much of a factor when used as an adhesive, or possibly as noticeable for consolidation of darker colored materials. Some areas of the Kizil paintings that needed to be stabilized were white in color, however, and so further investigation into the long-term properties of PVB was undertaken.


Our Lab Studies of PVBs
• Previous work; our materials, methods
• UVA light testing
• Museum light testing
• PVBs on plaster of Paris
• Comments on conservation
AIC RATS



Important previous study, published in 2007

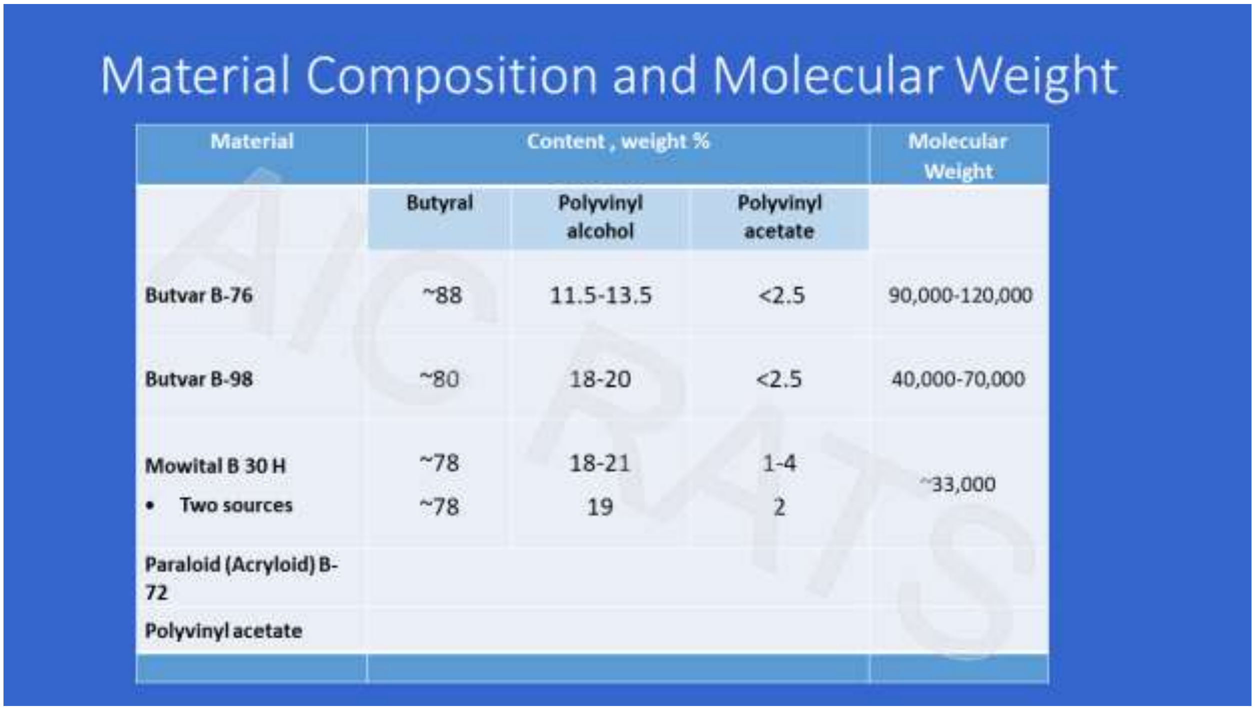
Graph shows Mowital B30T data: Highly accelerated degradation with UVB

Oxidation produces peroxides, with initial weight gain

Followed by carbonyls and volatiles, with weight loss

Yellowing and embrittlement

Feller, et al used four different lamps (UVB, UVA, BLB, and high-output “daylight” fluorescent (DLF) lamps and three different PVBs, Butvar B-79, Mowital B30HH, and Mowital B30T, but only studied B30HH with all of the different lamps.



Material Composition and Molecular Weight

Material	Content , weight %			Molecular Weight
	Butyral	Polyvinyl alcohol	Polyvinyl acetate	
Butvar B-76	~88	11.5-13.5	<2.5	90,000-120,000
Butvar B-98	~80	18-20	<2.5	40,000-70,000
Mowital B 30 H • Two sources	~78 ~78	18-21 19	1-4 2	~33,000
Paraloid (Acryloid) B-72				
Polyvinyl acetate				

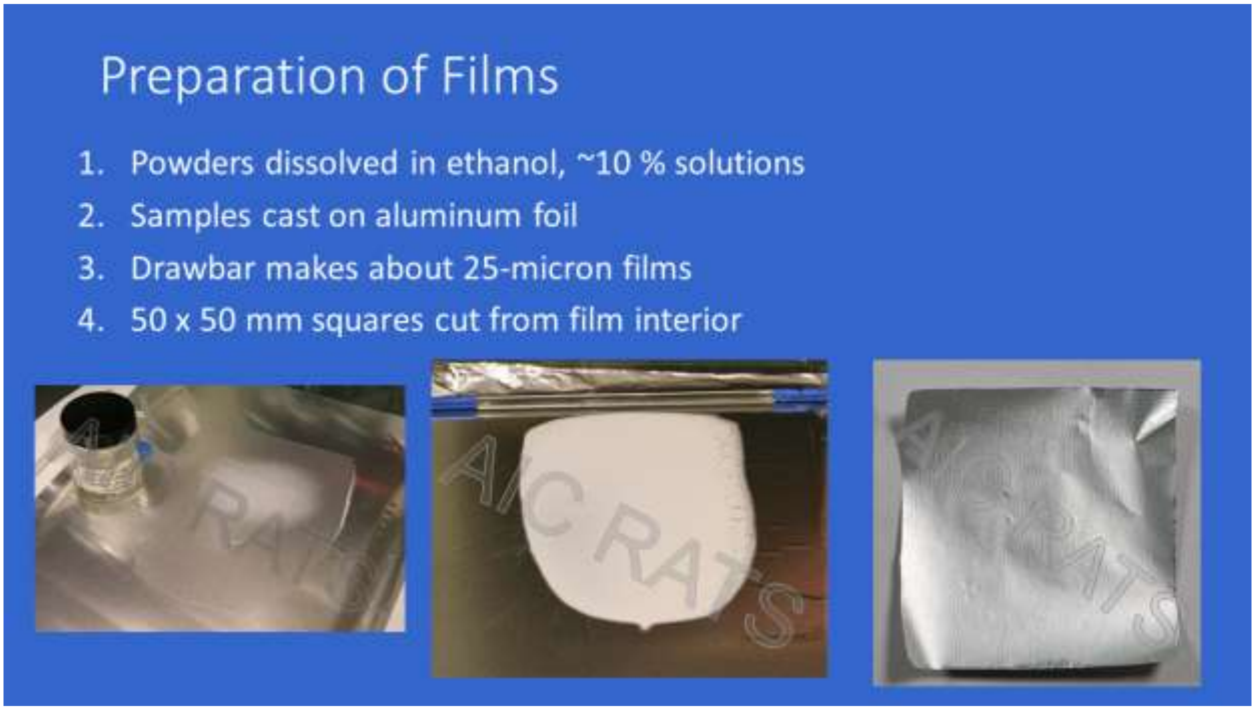
PVBs are those normally available from conservation suppliers

In 2007, Butvar was made by Monsanto (now Eastman, six different grades)

Mowital was made by Hoechst (now Kuraray, several grades))

B-72 and PVAC for comparison, but focus is on PVBs.

B-72 is an acrylic copolymer, poly (methyl acrylate/ethyl methacrylate)



Typically 10% solutions result in films about 25 micrometer thickness. Solutions vary from about 8 to 12% to achieve a convenient viscosity for spreading with the drawbar.

B30H is a finer powder and dissolves more readily than Butvars, but Butvar solutions are still prepared without difficulty

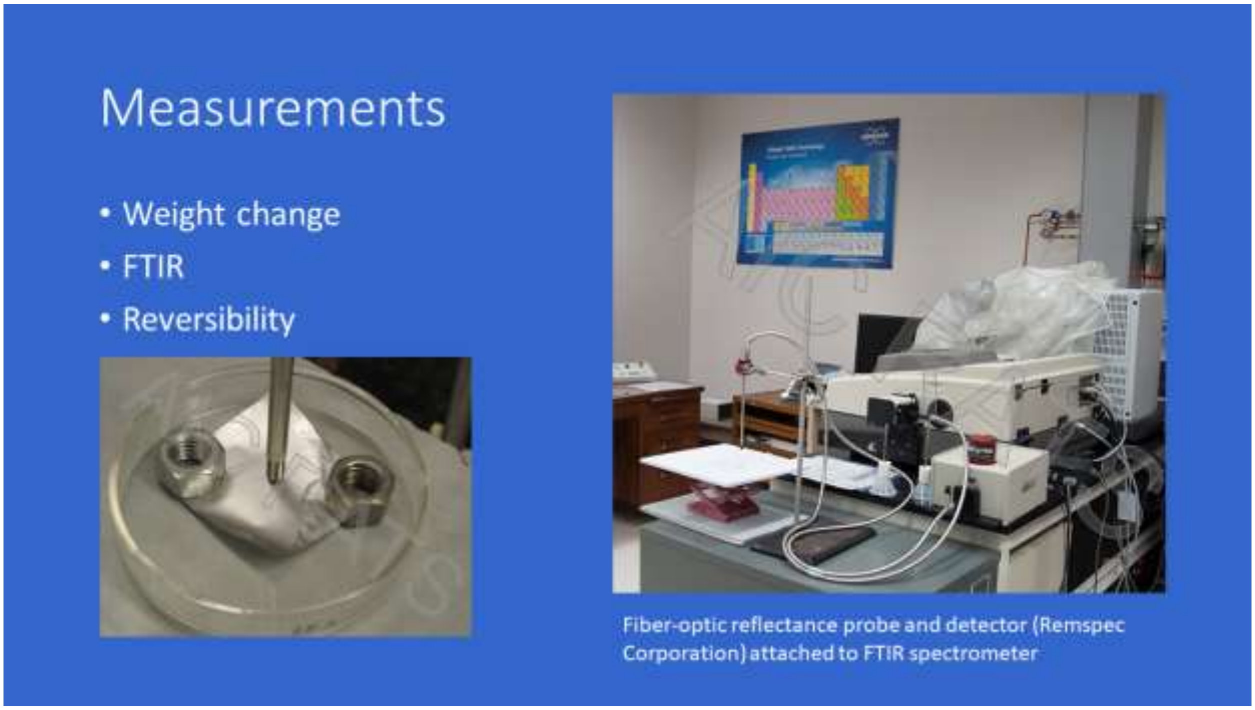
Aluminum foil on large glass plate, adheres with several drops of acetone

Doctor blade is glass rod with tape wrapped around ends for separation

Dragged slowly across small pool of PVB solution to form a film

On left is chamber used for UV ageing. Film samples on foil squares were placed in petri dishes and put in chamber for ageing.

Films also were made on cards for Transmission FTIR. Results confirm that fiber-optic spectra are of the same high quality as obtained by conventional FTIR methods.

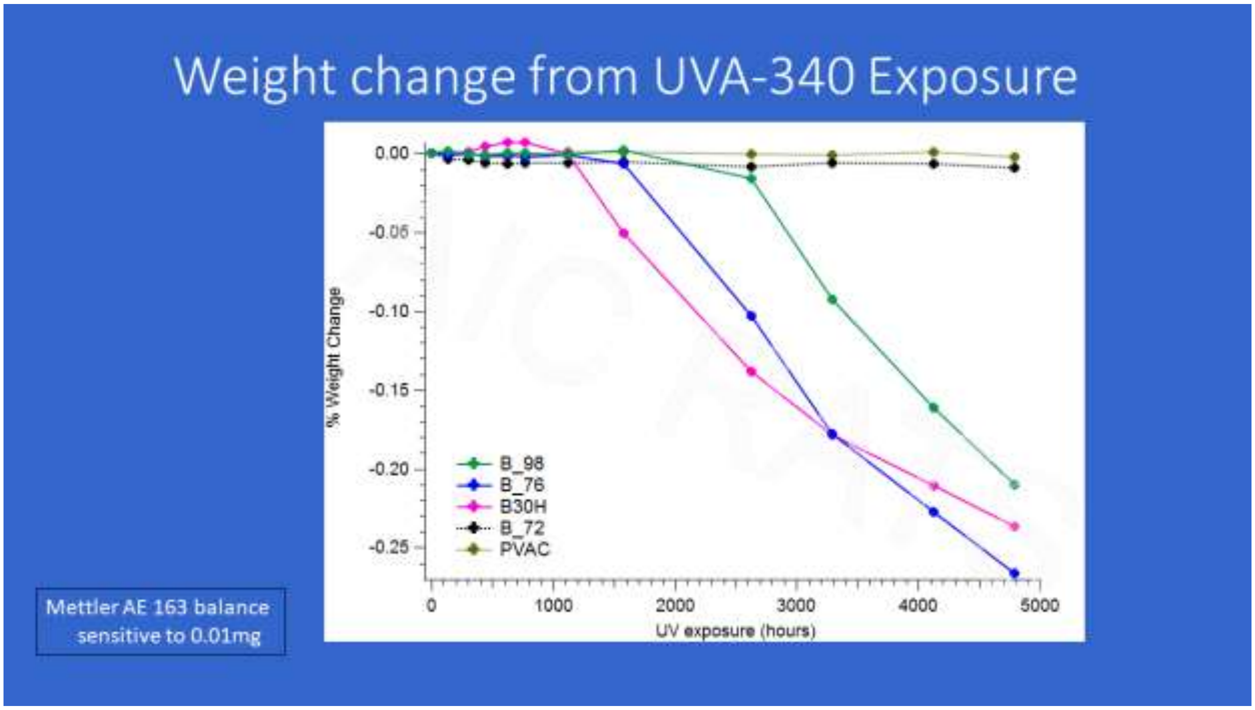


Weight change, following Feller et al.

Thermo Nicolet Nexus 670 spectrometer with Remspec fiber optic probe and detector.

Standoff distance of fiber optic probe about one millimeter

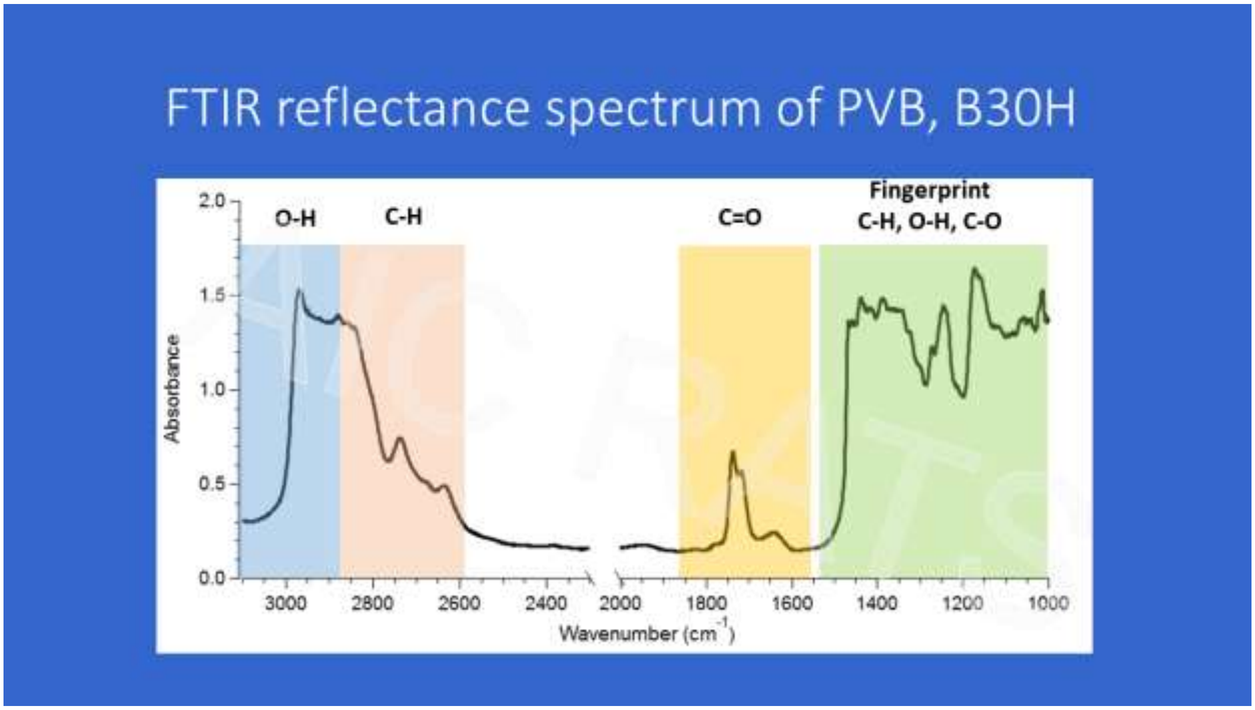
No contact of probe with sample.



Sample dried for 1 hour then immediately weighed with high precision balance.

Eliminates concerns over moisture absorbance.

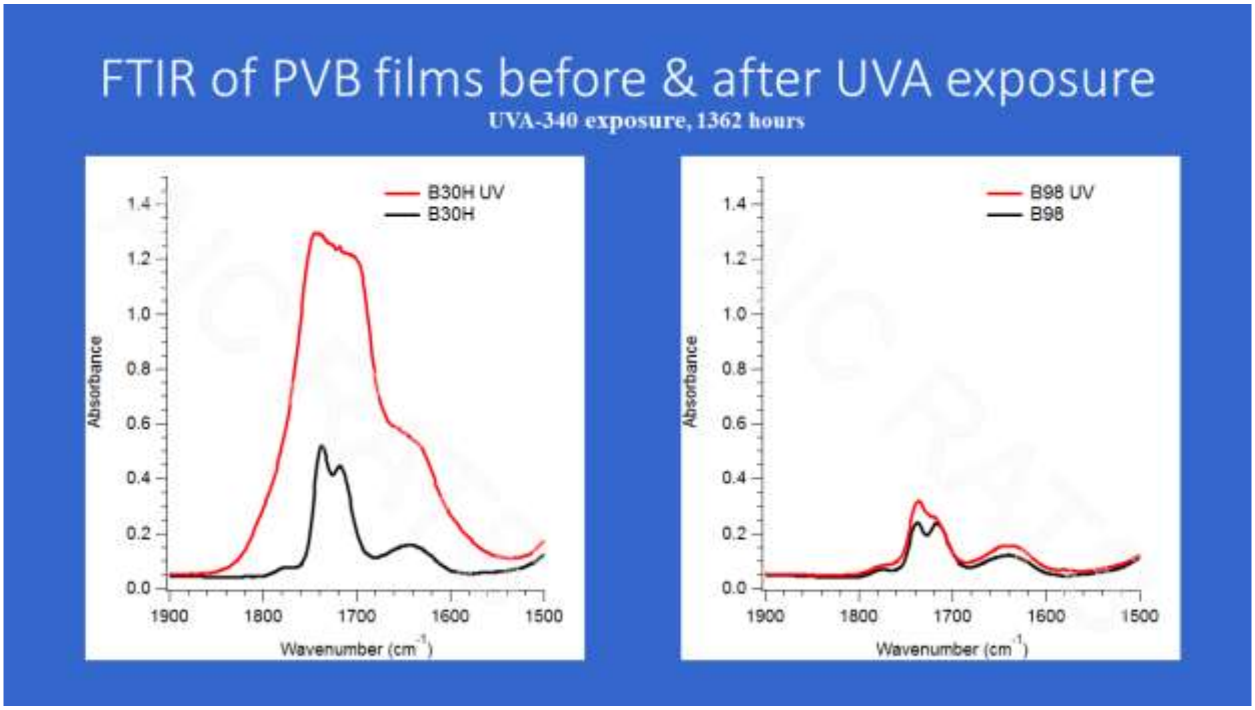
B-72 and PVAC were fairly stable. All three PVBs showed weight decreases over time of exposure. This relates to the oxidation of the film and subsequent release of volatiles that correspond to changes from the degradation of the films.



*Very rough assignments. Not differentiating between stretch, bend, etc.

Will focus on the C=O stretching area, specifically on carbonyl peaks at about 1740.cm-1.

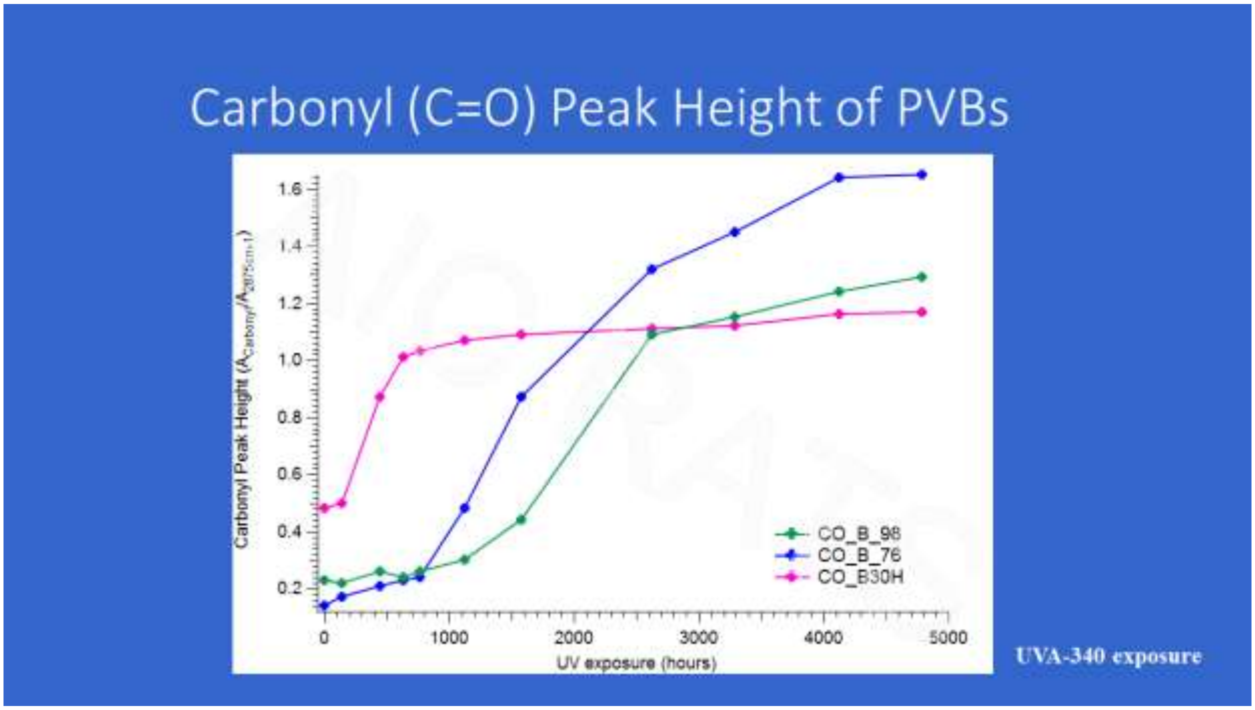
Reference materials Paraloid B-72 and PVAC have a much larger carbonyl peak



UV exposure 1362 hours

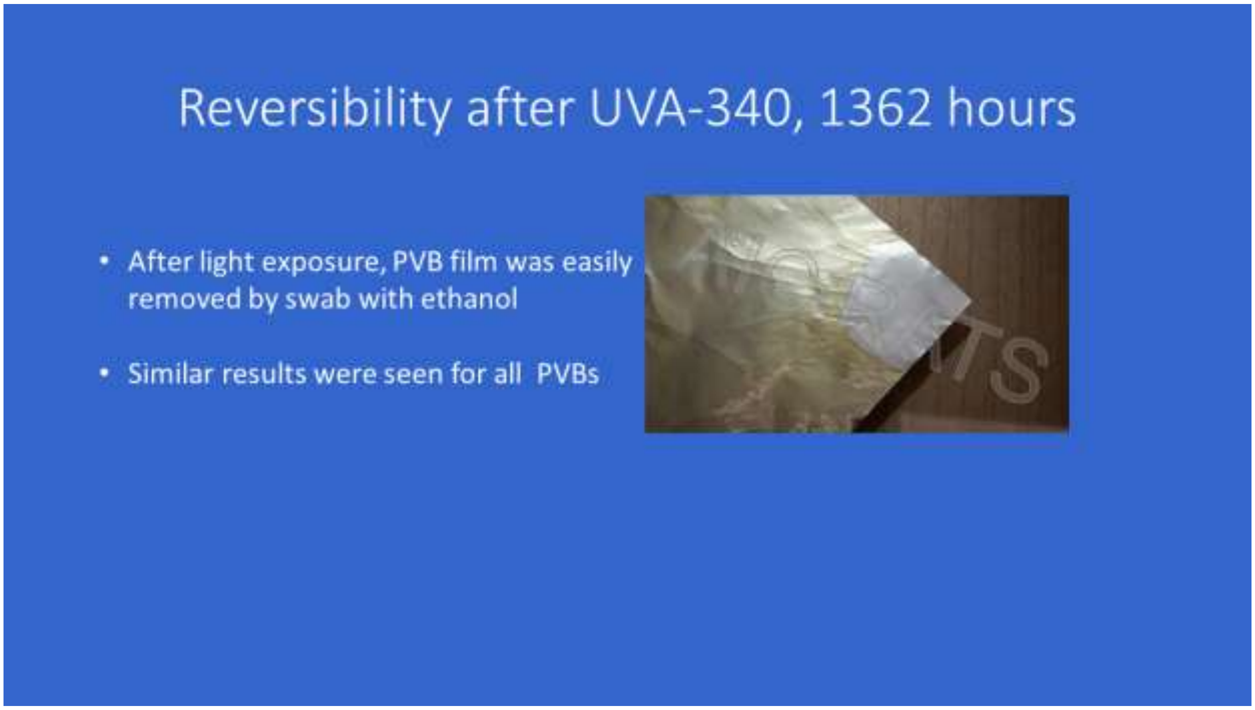
C=O bands indicate increased oxidation with UV time.

These are representative of several hundred IR spectra in the UVA part of this study.



Note difference in carbonyl peak heights of B98 and B30H, initially and at 1362 hours

Due to the difference in behavior from Butvars of similar composition, 2 separate batches of B30H (from different years and sources) were run, and results stayed the same.



Sample swabbed with ethanol shows that the film can be easily removed after light exposure.

Above is B30H on Al foil.

Yellow area shows cracking from flexing.

This combination of lamp and filters is commonly used in conservation to simulate sunlight filtered through pane glass.

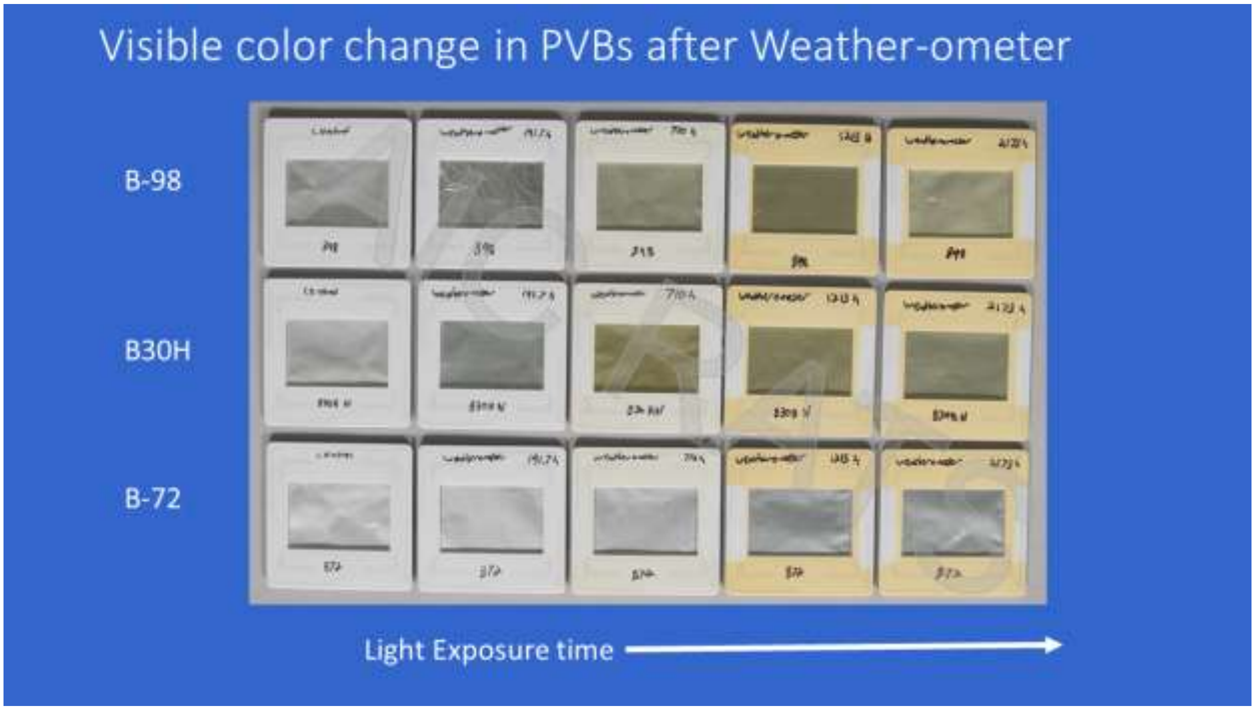
Similar to conditions used for the testing of varnishes.

It still contains some UV in the UVA region. UV content more similar to UV-351 lamps.

The temperature is well below the polymer glass transition temperatures.

Very roughly the arc lamp light is 350x stronger than gallery at 200 lux.

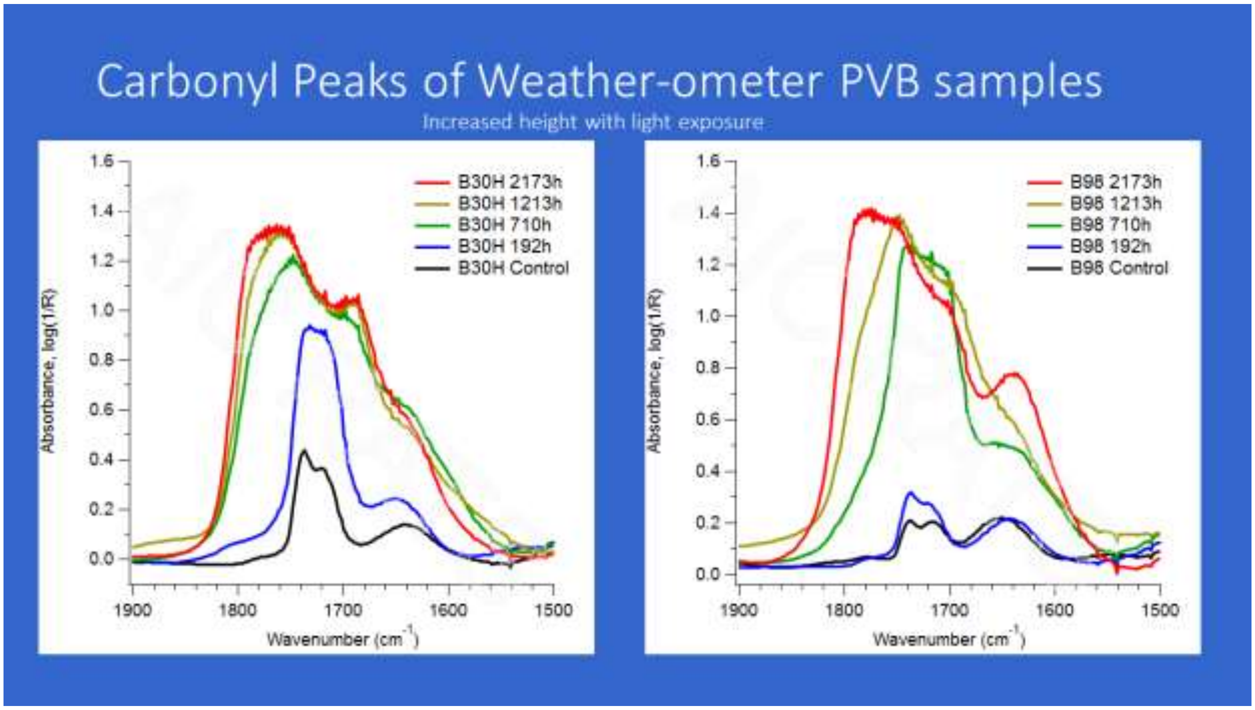
Black panel temp monitor. Monitor at 420 nm (0.9 W/m^2).



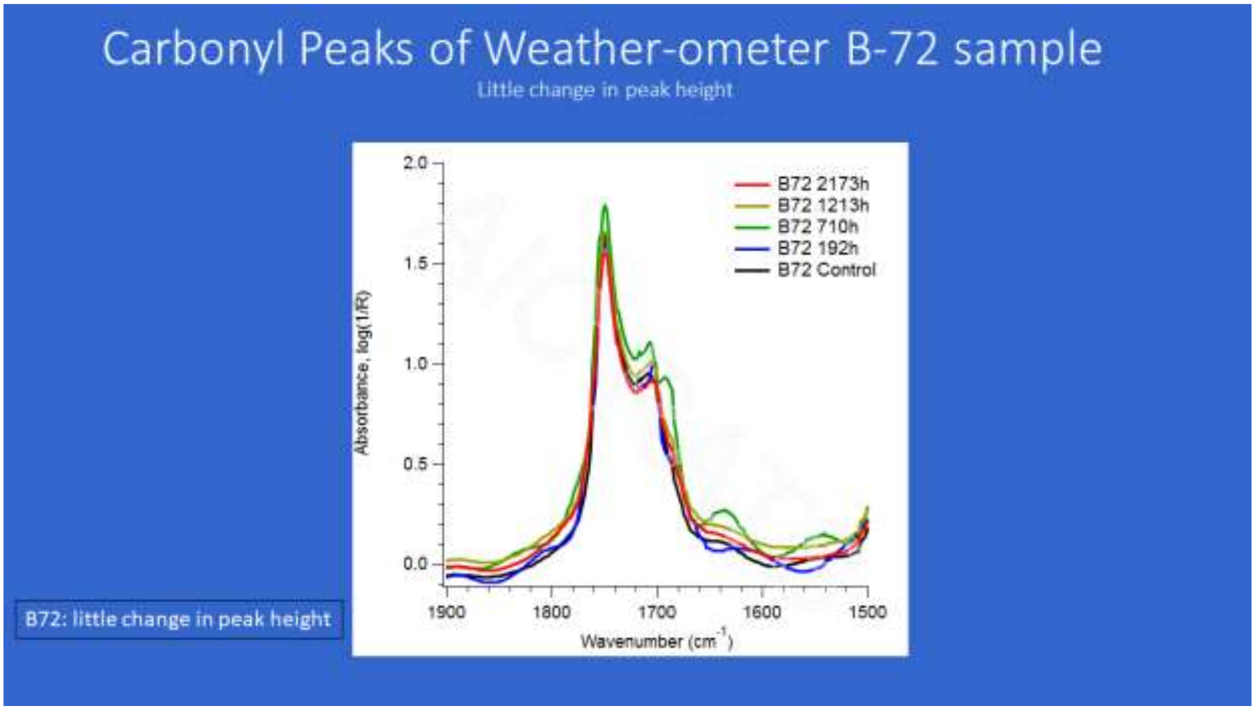
Weather-ometer times are: 192 hours, 710 hours, 1213 hours, and 2173 hours.

Very rough equivalents for light aging are: 8 years, 28 years, 48 years, 87 years.

When initially removed, the films initially appear colorless. The yellowing occurs over time in the dark.

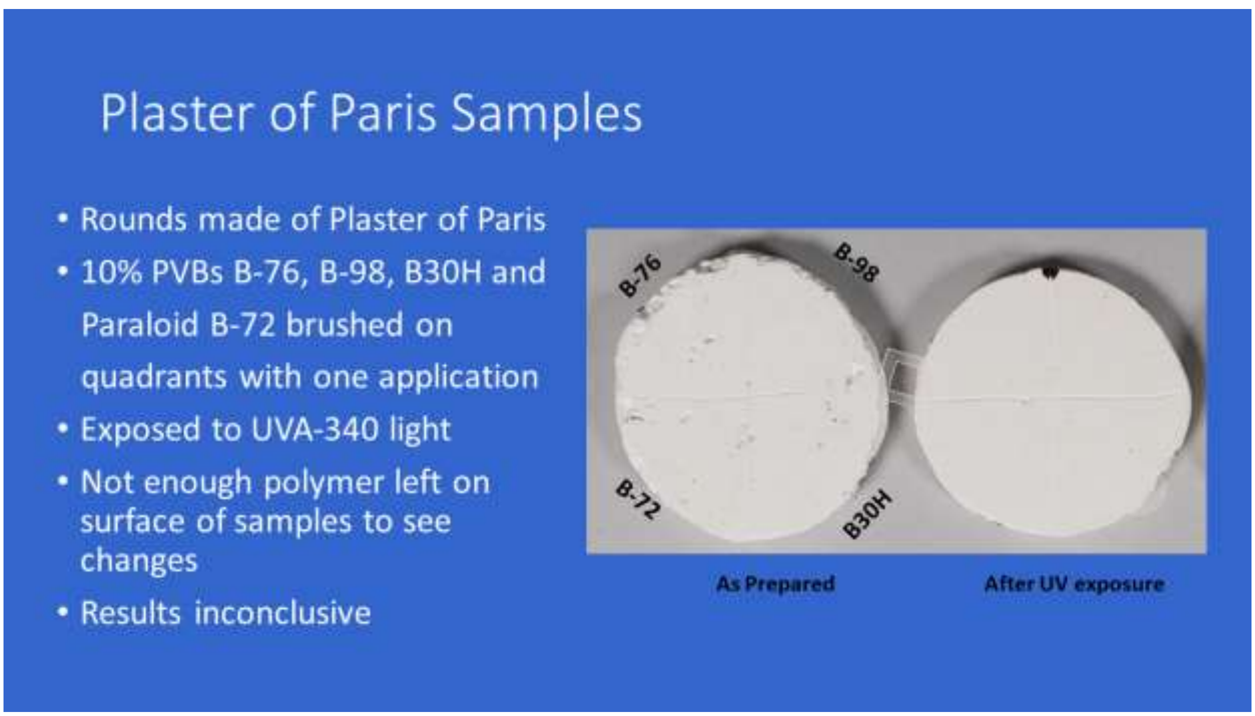


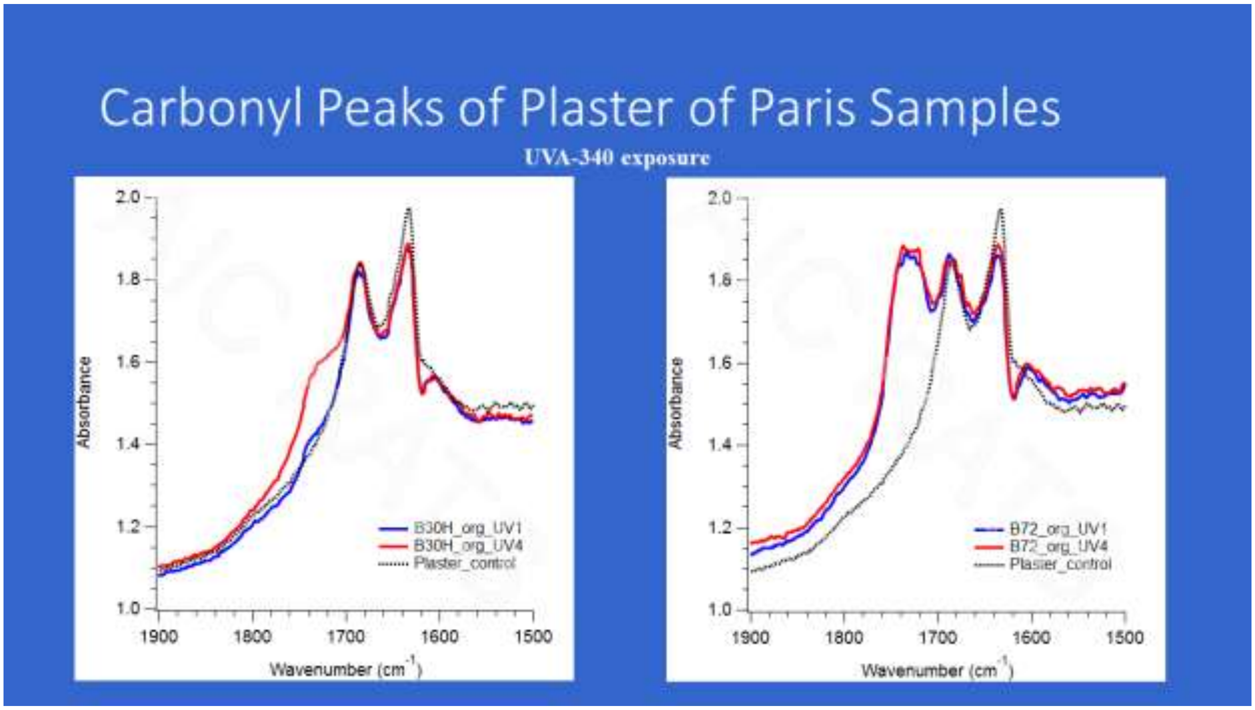
Carbonyl peaks increase in height due to exposure to light. Trends are the same for B98 and B30H as those seen under UVA light. Spectra for the weather-ometer samples were acquired by a Nicolet Continuum FTIR microscope in reflectance mode.



Very high carbonyl peaks in B-72 (and also PVAC)

Little change with light exposure (also true for UVA-340 exposure)





On right side, black dotted line shows large double peaks characteristic of Plaster of Paris, at about 1630 and 1690 cm-1. Large carbonyl peak characteristic of B-72 acrylic shows no change with UVA-340 exposure.

Spectra on left show growing carbonyl peak of degrading B30H, as shoulder on left side of Plaster of Paris double peak.

As noted, not sufficient sample on surface for conclusive results.

Conclusions

- PVB degradation can be tracked by carbonyl peaks using FTIR spectroscopy
- Fiber-optic reflectance spectroscopy had required resolution, and is non-contact
- PVBs gradually oxidize and yellow, but retain solubility in ethanol
- B-98 and B-76 did not yellow as rapidly as B30H. All PVBs yellowed more than B-72
- Changes were similar under UVA-340 and filtered daylight conditions, but sooner with UVA-340
- May be suitable as consolidant, if color change is not easily visible on object
- Color change less of an issue for joins, but did not test strength or suitability as an adhesive

Acknowledgments

- Freer|Sackler Department of Conservation and Scientific Research
- Smithsonian Institution Behind-the-Scenes Volunteer program
- Michael Palmer, National Gallery of Art
- Helen Ingalls and Department of Conservation, Smithsonian American Art Museum
- Peter Melling, Remspec
- Kuraray

Understanding the Reactivity and the Dynamics of Lead Soaps in Oil Paintings

Jaclyn Catalano, Anna Murphy, Yao Yao, Nicholas Zumbulyadis, Silvia Centeno (presenter), Cecil Dybowski

To understand the mechanisms and factors that trigger soap formation and the dynamics of the reactive compounds in oil paintings, we used advanced solid state nuclear magnetic resonance (ssNMR) and X-ray techniques, complemented by FTIR spectroscopy. We explored soap formation in model paint films at different relative humidity conditions by 13C NMR and studied the dynamics and mobility of relevant fatty acids and soaps, namely palmitic acid and lead palmitate, in a linseed oil matrix at different temperatures (T) by 2H NMR. The results show the extent of mobility of palmitic acid and lead palmitate in the paint matrix, how they differ, and how they depend on T. Examination with techniques such as solid-state 207Pb, 119Sn, and 13C NMR, and X-ray diffraction provided the basis for interpreting dynamics in terms of the effects of structure and lead ion coordination environments [1-5]. The ssNMR results obtained in model paint samples directly correlate with features of the IR data, so they are useful to further interpret FTIR spectra acquired in microsamples removed from works of art. Also, the ssNMR data sets the basis for minimally invasive NMR studies in microsamples with the development of dynamic nuclear polarization (DNP) techniques. The results will be discussed in the context of their implications for the conservation and preservation of the works of art affected by lead soap formation.

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What can Nanotechnology do for Us? Evaluating Novel Cleaning Tools Through the NanoRestArt Project at Tate

Bronwyn Ormsby, Lora Angelova, Rachel Barker, Gates Sofer

Tate is currently a partner in the Horizon 2020-EU funded project 'Nanorestart'– a multinational research initiative to introduce nanotechnology solutions to the conservation and preservation challenges of modern and contemporary art. The project aims to address four distinct conservation challenges: (1) the controlled surface cleaning of contemporary materials, (2) the stabilisation and consolidation of canvases and painted layers (3) the development of sensors and substrates for enhanced molecular detection and analysis, and (4) the creation of enhanced protective coatings. All of the tools and materials being investigated aim to introduce nanotechnologies such nanocontainers, nanoparticles, nanosensors, etc., to the collection care toolbox. Tate's role in Nanorestart is primarily focused on the evaluation of novel cleaning systems which include highly-retentive gels for the confinement of enzymes and nanostructured fluids based on green surfactants. Over the course of the project, we will carry out analyses and treatments on three artworks from the Tate collection in conjunction with sculpture and paintings conservators. The artworks include a plastic object, an acrylic (solution) painting, and an acrylic (emulsion)-painted mixed media object. Each treatment will be approached as a complete case study and will include extensive scientific analyses and technical examination, preparation of mock-ups, characterisation of the mock-up surfaces before, during, and after treatment with a large suite of systems (including those currently available to conservators), evaluation of the optimal cleaning approach based on scientific and conservator evaluations, and finally, the surface cleaning treatment of the artwork. The process and results from our first two case studies will be presented in detail – Michael Dillon's Op Structure, 1967, and progress made on Roy Lichtenstein's Whaam!, 1963. Dillon's Perspex® (poly(methylmethacrylate)) Op Art object does not show significant signs of degradation; however, the surface has areas of fingerprints and light soiling, and there are two different types of adhesive labels which will be removed. The high gloss and susceptibility of the polymer to solvent cleaning and abrasion make this treatment complex and very relevant to contemporary art collections. At present, mock-ups based on the artwork materials have been prepared and characterised; more than 60 treatment options will be explored for soiling and adhesive removal prior to approaching the artwork. Lichtenstein's iconic piece is painted primarily with Magna acrylic solution paints, as well as oils and oil-modified alkyds. The 'seam' between the two canvases of the painting's composition has become distracting due to surface soiling and other marks. This case study will commence at the start of 2017, and the results, challenges, and the decision making process leading up to the treatment (to date) will also be presented. The research for this study received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646063

2017 – Research and Technical Studies and Book and Paper Specialty Group Presentations

Centuries of Cellulose: Lessons Learned from the Molecular Size of Cellulose in Naturally-Aged Paper Collections

Andrew Davis, Fenella France

Size-exclusion chromatography (SEC) has been used successfully for many decades as a tool to quantify the molecular structures of large synthetic polymers and to draw connections between molecular size and material properties. In contrast to the success of SEC for measuring synthetic polymers, paper and cellulosic polymers provide inherent difficulties for similar chromatographic analyses. Improvements in instrumentation and experimental procedures have slowly and markedly improved the current state of molecular characterization of cellulose by SEC. This work begins to draw connections between the size distributions of cellulose molecules to the known properties of variously treated and aged collection materials. The Barrow Books Collection at the Library of Congress provided an excellent starting point for using SEC in complement with other analytical techniques, both non-invasive and destructive, to evaluate the long term stability and treatment of paper-based collections. Existing data from the well-characterized collection includes chemical-scale properties (e.g., pH and chemical functionality) up to macro-scale properties (e.g., mechanical strength and colorfastness). However, a gap has long existed between these two scales. Little data is available at the scale of polymeric macromolecules, where initially minute chemical changes eventually translate to macroscale degradation. Recent work from the Preservation Research & Testing labs at the Library of Congress has used both the Barrow Books Collection as well as a selection of paper from American sources to investigate how SEC might be used to complement existing conservation data and analyses. For example, SEC quantifiably identifies the consequence of alkali treatments on preserving cellulose polymer chain lengths, which strongly correlates to eventual paper embrittlement. Attempts at correlating new experimental data with existing data from books in Library's collection also demonstrates the inherent challenges and opportunities for using SEC to identify structure-property relationships between the molecular structure of cellulose and the properties of aged paper collections. Assessing various conversation treatments in this way could better inform conservators on predicting the efficacy of paper preservation treatments. It appears likely that minute changes in the statistical distribution of polymer sizes in aged paper, easily measured by SEC, could provide an early indicator of degradation and might allow improved design of artificial aging studies. More effectively linking micro analytical determinants to current destructive mechanical testing is critical for assessing use and condition of paper based historic collections.

Characterization of Aniline Dyes in Colored Papers of Jose Posada's Prints Using (ToF-SIMS) to Aid in Developing a Treatment Protocol for the Removal of Oxidized Tape

Stacey Kelly, Ashley Ellsworth, Jenny K. Hedlund, Jodie Lee Utter, Amy Walker

Jose Guadalupe Posada (1852-1913) was a prolific and influential Mexican printmaker; he produced thousands of images printed on a variety of poor-quality papers, often colored with vibrant but fugitive aniline dyes. The Amon Carter Museum of American Art has a large collection of approximately 400 prints attributed to Posada, many of which retain their bright color. A number of these are unstable due to oxidized pressure-sensitive tape residue, penetrating and weakening the short-fibered paper. In addition, aniline dyes are sensitive to solvents, complicating treatment.

Because aniline dyes have varying sensitivities to different solvents it is necessary to characterize them before an appropriate treatment protocol can be developed. A previous study of Posada's prints identified several aniline dyes using Fourier Transform (FT)-Raman spectroscopy. Of these, the yellow dyes could not be fully characterized. In this study, time-of-flight secondary ion mass spectrometry (TOF SIMS) was used to discern the dyes present in the colored papers with particular focus on the yellow dyes.

TOF SIMS is a valuable analytical technique for the identification of organic and inorganic components. Its high sensitivity and small sample size requirements make it potentially useful for the analysis of dyes and works on paper. For this study a selection of Posada's prints in various colors from the Amon Carter's collection were examined using TOF SIMS. Preliminary analysis has produced significant data for all the dyes analyzed. FT-Raman analysis was also conducted on these prints to verify the results.

As part of developing a treatment protocol for the Posada prints, an experiment was set up using artificially aged paper and tapes to simulate the removal of oxidized tape from fragile dyed papers. A variety of methods were employed. Samples were created by applying Scotch MagicTM tape (acetate backing; acrylic adhesive), 3M 2214 paper tape (crepe paper backing; rubber adhesive), gummed brown paper tape (kraft paper backing; starch adhesive), and Slime rubber cement to several c.1900s dyed and undyed broadsides, mimicking the Posada prints. The samples were then 'treated' with solvent and suction, solvent vapor, solvent through Gore-tex sandwich, and rigid Gellan gum with solvent. The samples were imaged using visible light and Ultra-Violet (UV) before and after treatment, along with spectrophotometer readings to monitor and record any changes in the samples.

Because aniline dyes are prevalent in many turn of the century objects, as are oxidized tapes, developing an effective treatment protocol has tremendous potential benefit.

The Codex Eyckensis (8th century). Re-evaluation of the 20th Century Restoration & Conservation Treatments

Lieve Watteeuw, Marina Van Bos, Bruno Vandermeulen

The Codex Eyckensis was most probably written at the scriptorium of Echternach (Luxembourg) in the 8th century, and was brought to Aldeneik (northeast Belgium) by Saint Willibrord. This restrained pre-Carolingian codex is a splendid example of the dynamic confluence in the 8th century of the insular formal idiom and the artistic characteristics developing on the European mainland. After the drastic conservation treatment of 1957 with heat sealing plastic foil, the Codex Eyckensis (8th century) was fully conserved in the nineteen-nineties by removing the Mipofolie lamination of the parchment and recreating the missing areas with parchment pulp. Since the conservation was finished in 1992, the manuscript was kept in the crypt of the Saint Catherine's church, a place with a highly instable climate. After 25 year the need for a re-assessment of the Codex Eyckensis urges itself, the more that the possibilities for in depth research have developed considerable. In the ongoing survey, the condition of the parchment and the stability of the leafcasting with parchment pulp is evaluated. Multispectral imaging and material-technical analyses aim to shed light on the condition and the creation of the writing and illuminations of the pre-Carolinian codex. In the new study project (2016-2018), 25 years after, the codex will be re-assessed using non-destructive analytical and imaging techniques. Linking conservation information of the past (1992) with new data, will evaluate protocols applied at the end of the 20th century and contribute to the future preservation of the Codex Eyckensis. During the campaign in the nineteen-nineties, no material technical analyses have been carried out. The combination of XRF, XRF-mapping and Raman spectroscopy are used to characterize the materials and inks used in the Codex Eyckensis. The removed Mipofolie foils have been archived since the treatment in 1992. These foils were highly adhering to the parchment, it was not always possible to remove the PVC foils without removing some small paintfragments. These are analyzed using complementary but destructive analysis techniques aiming at the identification of organic components (binder/colourant). Complementary with the analytical data, imaging will contribute to the condition evaluation and material characterization. Within the framework of RICH (KU Leuven) a multispectral, multi-directional, portable and dome-shaped acquisition system has been developed to imagine with photometric stereo. Visualisation of pigments can be realized based on reflection maps. These findings are evaluated using the data obtained in a laboratory set-up and using the data obtained through XRF, XRF-mapping and Raman. The new assessment and technical study of the Codex Eyckensis is reflecting the complex material and conservation history of the 8th century codex. As the treatment was well documented 25 years ago, the new data are adding multiple layers of information. This research provides new insights into the origin and the creation of the illuminations and contributes to the in depth knowledge of the oldest manuscript kept in the Low Countries. The

study gives reflection to the dynamics of conservation history, the importance of ongoing data collecting, revealing new challenges in technical documentation with recent imaging techniques and non-destructive analytical tools.

Contacts that Leave Traces: Investigations into the Contamination of Paper Surfaces from Handling

Karin van der Pal, Wilhelm van Bronswijk, Simon Lewis, Rachel S. Popelka-Filcoff, Gregory D. Smith

The contamination of paper surfaces during the process of handling documents is a significant issue for forensic scientists and conservators. In the forensic context, it has been found that polyvinyl chloride and latex gloves would leave handprints on porous and non-porous surfaces after 20-40 minutes of wear by a subject.[1] Anecdotally, it has been seen by both forensic practitioners and by fingerprint researchers at Curtin University that nitrile gloves can also leave fingermarks on paper after periods of wear. The issue of whether to wear gloves or not to wear gloves when handling documents has also been a matter of controversy in the conservation and archivist community.[2] Prue McKay at the National Archives of Australia carried out some preliminary studies to determine the potential for contamination from gloved and non-gloved hands when handling paper items.[3] However other than the papers mentioned above there is a paucity of published research in this area. A research project has been initiated at Curtin to explore this issue by using a range of forensic fingerprint techniques to investigate the level of fingermark contamination on paper items handled with bare and covered hands. Subsequently, the effect of latent fingermarks on paper items will be investigated using artificial aging. This presentation will give an overview of the background of the methods to be used as well as presenting some of our initial results. Acknowledgments: The authors thank Terry Kent and Prue McKay for useful discussion concerning this research.
References [1] Willinski G. J Forensic Sci. 1980; 25(3):682-685 [2] Baker C.A and Silverman R. International Preservation News. 2005; 37: 4-17 [3] McKay P. 5th AICCM Book, Paper and Photographic Materials Symposium. 2008; 1-10

Lessons from a Large-Scale Survey of Parchment Animal Origin and Production Quality

Matthew Collins

Parchment manuscripts sit at the nexus of digital, biological and physical sciences, history, art, and literature. Can a simple PVC eraser link these together? Traditionally, an eraser is an article of stationery used to remove writing from paper. Yet when combined with biomolecular analysis it can also be a medium to ascertain the animal identity and production quality of medieval manuscripts. The eraser strokes the parchment generating a strong electrostatic charge which lifts the grime from the parchment surface; trapped in the grime are tiny amounts of biomolecules from the parchment itself, small samples yes, but enough to be analysed by modern instruments. Parchment books and documents are the fundamental vehicle for the transmission and preservation of a millennium's worth of written culture. Hence their systematic study (palaeography, codicology and diplomatic) have long been recognized as essential disciplines for many areas of humanistic study. For scientists, however, the parchment record of the past represents an unrecognized and untapped reservoir of genetic and biological information. And because a considerable number of parchment books and documents can be precisely dated and localized--the molecular information derived from them has enormous yet largely unrealized value for the fields of bioarchaeology, paleozoology, anthropology, and historical ecology. Both manuscript studies and biomolecular research are, in a sense, forensic: the former, because the disciplines of palaeography and codicology depend on exacting study of regularities in human production of one class of artefact; the latter, because biomolecular analysis yields the DNA of the animal that provided each individual leaf. However, these disciplines currently stand at opposite ends of the epistemological spectrum. Students of manuscripts and texts have long recognized that the most exacting study of individual artefacts is the necessary foundation of their work, even when they seek larger patterns. Science in contrast is moving towards a new mode of cognition enabled by mechanical information generation techniques. Colloquially known as 'Big Data', this new approach turns the old hypothetico-deductive model on its head to harvest data and share it across networks so that analysis is done by large teams seeking patterns in the data rather than seeking to corroborate prior hypotheses. With the collaboration of colleagues worldwide who have sent us eraser shavings from parchment we are building up evidence of the exploitation of past animal populations and their distribution in time and space, and are adding a new category of evidence concerning the provenance of unlocalized manuscripts.

Revisiting paper pH determination: 40 years of evolving practice in the Library of Congress

Cindy Connelly Ryan, Eric Breitung, Lynn Brostoff, Michele Youket

Extended Abstract

The pH of paper is a fundamental indicator of its long-term stability, and is routinely considered by conservators, cultural heritage scientists, and collection care professionals in the process of making decisions about collection storage, handling and access policies. The results of pH testing are frequently considered as part of conservation treatment planning, and are nearly always included in research studies related to paper preservation.

This seemingly basic and familiar measurement, however, contains a depth and complexity that becomes apparent when pondering the differences between the industrial TAPPI methods, ISO standards, both cold extraction and hot extraction, and the numerous published variant methods, including surface measurement methods and miniaturized methods. Are the results comparable between the different methods? Which approach is best?

Over the last few years, PRTD has revisited its standard protocols for pH measurement of paper and board in the contexts of quality assurance needs for collection housing and exhibition materials, scientific research studies, and special collections projects. The various methods in use in our lab date from the early 1970's to the present. These will be discussed, with focus on our recent efforts to develop a reliable miniaturized pH determination method and to streamline our semi-automated measurements. This talk will also include a short discussion of the fundamentals of paper pH measurement, focusing on how aspects of sampling, sample preparation and measurement method affect the results obtained. As part of this review process, a set of sample papers and boards were tested using six different pH measurement protocols, permitting direct comparison of the repeatability and values obtained between methods. The protocols compared include three TAPPI standards: hot extract, cold extract, and surface; the ISO cold extraction method; a pulped extraction method, used in-house since the early 1970's; and a miniature method recently developed in-house.

Our findings point out the importance of considering your sample's characteristics when selecting a measurement method, as well as your project's requirements for accuracy, speed, or sample consumption. These results also demonstrate the impact of protocol variations on practical application. Surface measurement had poor repeatability, and mis-read alkaline, thick/layered, and gelatin sized samples. Differences in speed, ease of execution, values obtained, and repeatability were seen between the different extractive methods. The miniature method compared well in values and repeatability to the macro-scale results, though the inhomogeneity of aged papers can affect results at this scale.

2017 – Research and Technical Studies and Paintings Specialty Group Presentations

A Confusion of Colors: Yellow and red pigments in the decorative scheme of the tablinum in the House of the Bicentenary at the archaeological site of Herculaneum

Leslie Rainer, Kiernan Graves, Gilberto Artioli, Arlen Heginbotham, Francesca Piqué, Michele Secco

The conservation of the architectural surfaces in the tablinum of the House of the Bicentenary at the ancient Roman site of Herculaneum is a collaborative project of the Getty Conservation Institute, the Herculaneum Conservation Project and the Soprintendenza Pompeii. As part of this project, a study was undertaken by a multi-disciplinary team comprised of conservators and conservation scientists to understand the effects of the catastrophic 79 CE eruption of Mt. Vesuivus on the wall paintings at Herculaneum. Due to the eruption, Herculaneum was destroyed as a living city, and yet preserved nearly intact for two millennia, buried under twenty meters of volcanic material. Discovered in 1709, and excavated as an open-air site in the early to mid-twentieth century, Herculaneum preserved a wealth of Roman cultural heritage, including the exquisitely painted walls of the tablinum of the House of the Bicentenary. The decorative scheme of the tablinum is composed of red, yellow and black monochrome backgrounds with decorative borders and floral and architectural elements. In the center of each wall are figurative scenes emulating portable paintings. As a result of the eruption, the wall paintings suffered severe damage and alteration, notably in large swaths of yellow monochrome background converted to red when exposed to the heat generated by hot mud and ash from the volcano. This color shift significantly changed the appearance of the decorative scheme. The objective of this study was to distinguish the fields of original red monochrome background from the fields of red, which had converted from yellow due to heat from the eruption. The methodology followed for the study consisted of preliminary background research, a stylistic study of similar wall painting schemes in the region, and materials analysis to identify original and altered yellows and reds in the tablinum. Based on the background research, conservators and scientists worked together to develop an approach to analyze the monochrome fields of original and altered red paint in the tablinum in order to characterize their pigment compositions and differentiate between them. Portable X-ray fluorescence spectroscopy (XRF) was used in situ to map the monochrome backgrounds. Laboratory analysis, using optical and electron microscopy, x-ray diffraction, and micro-Raman spectroscopy, was conducted on representative samples collected from areas retaining original yellow color; areas thought to be originally red; and areas thought to be originally yellow, now appearing red. These analyses suggested that the paints were not made with pure ochre pigments, but contained admixtures of secondary materials in small amounts, which appeared to be different in the yellow and red fields. This paper will present the results of the research showing that the compositions of the original and altered reds were sufficiently different to be

distinguished from one another. The results of the study have contributed to a better understanding of the original decorative scheme of the room, and the implications for conservation and interpretation. Moreover, the methods developed here can be used to better understand Roman painting technology and potentially identify original and converted pigments at other sites in the Vesuvian region.

Gecko-inspired μ-Dusters for Cleaning: Ongoing Research and Potential for Art Conservation

Cynthia Schwarz, Hadi Izadi, Kyle Vanderlick

The presentation will report on the status of the ongoing research project on the use of μ-dusters in art conservation. Inspired by gecko adhesion, fibrillar microstructures (μ-dusters) show great potential as a dry cleaning material for removing particulate contaminants (loosely referred to as dust) from surfaces vulnerable to mechanical damage from dry cleaning, such as acrylic paintings and daguerreotypes. In collaboration with the Department of Chemical & Environmental Engineering at Yale University, we have demonstrated successful dust removal from a variety of solid surfaces using polymeric μ-dusters. When they touch a contaminated surface, μ-dusters of controlled interfacial and geometrical properties develop intimate contact with both surface contaminants and substrates. However, development of stronger interactions with the contaminants allow for their removal from the surface. Further, preliminary testing on poly(methyl methacrylate) (PMMA) thin films (as model substrates for acrylic paint) demonstrated that by moving the adsorbed particles from the tip to the side of the fibrils and consequently removing them from the contact interface, polymeric μ-dusters are less likely to result in abrasive action on the surface than solid flat dry cleaning materials. This new generation of dry cleaning materials is attractive for use in art conservation for this non-destructive quality as well as for the very low potential of residue deposition on the artwork's surface. While the method is primarily targeted at removing loosely bound contaminants such as dust, μ-dusters present an advantage over with traditional dusting methods, such as brushing or air flow in that they have been shown to remove sub-micrometric contaminants that are not able to be removed by these methods. Colorimetry and gloss measurements and photomicrographs will be taken of artificially soiled acrylic paint samples before and after soiling and cleaning. The results will be compared to existing dusting and dry cleaning methods. The micropillar cleaning material will be also evaluated based on user experience. Suggested areas of further investigation will be presented.

Pioneering Solutions for Treating Water Stains on Acrylic Paintings: Case Study Composition, 1963 by Justin Knowles

Maureen Cross, Maggie Barkovic, Olympia Diamond, Bronwyn Ormsby

This collaborative case study outlines the criteria leading to the treatment of disfiguring water stains on a large-scale, acrylic dispersion canvas painting: Composition, 1963, by the British artist Justin Knowles. Decision making factors include how the 'negative space' of the exposed acrylic-sized canvas impacted the understanding and interpretation of the work and thus influenced the treatment methodology. Investigations into the artist's practice provided an important context for a conservation treatment, which prompted an exploration into the use of agar gel as a delivery system for aqueous cleaning solutions.

Composition is a brightly colored hard-line geometric abstraction juxtaposed against an unpigmented acrylic dispersion-sized canvas. Accidental water damage produced tidal stains across the canvas, rendering it unexhibitable. In 1973 Knowles lost more than one hundred of his paintings in a studio fire, driving him into a twenty-six-year hiatus from painting. Very few of these early developmental works by this prominent contributor to the British Abstract Art movement survive, and therefore this was a significant opportunity to conserve this rare painting.

Determining the most appropriate conservation treatment was complicated by both a lack of research into the treatment of water stained canvases, and the presence of an unpigmented acrylic dispersion-size layer. Investigation into the relationship between materials and meaning in Knowles' work, along with the cleaning of acrylic paintings, textiles, and works on paper aided in the development of a tailored cleaning solution to minimise risks to original materials whilst also facilitating the reduction of the stain.

The painting materials were characterized using microscopy, IR, and UV fluorescence, FTIR spectroscopy and XRF analysis. FTIR spectroscopy confirmed the presence of a p(EA/MMA) acrylic dispersion copolymer medium in both the paint and the unpigmented size. From these investigations, six water-stained test canvases were created, light aged for two years under museum conditions[i] , and then naturally aged for one year in dark storage. These samples were used to assess the effects of twenty-two aqueous cleaning solutions, applied both in solution and through agar gel. The results were evaluated using colour measurement[ii] and through visual observations by four paintings conservators. The effect of the preparation of the agar gel and the way it was applied were evaluated through a series of studies. Potential changes to the sized canvas surface were investigated using optical microscopy, Hirox 3-D digital microscopy[iii], highlight-based RTI, Atomic Force Microscopy, SEM, and FTIR-ATR spectroscopy. The results showed changes in surface morphology, which supported the need for designing optimal methods for both the preparation and application of the cleaning systems.

The painting treatment proceeded successfully to the point where the stain was substantially reduced. Retouching was the final stage of treatment aiming to reintegrate treated areas with the original surface, focusing on matching color, texture and gloss. A number of retouching media commonly used on acrylic paint were evaluated, and a successful method was found with Aquazol 50. As a result of this applied, collaborative research, a unique and important work has been successfully returned to displayable condition.

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[i] Conditions in the light box were at ~ 28°C and 22% RH. UV was filtered out from the light bulbs. Assuming reciprocity of exposure at 200 lux for 10 hours a day for 730 days (2 years) with an average lux in light box of 7,980 lux resulted in 183 hours exposure in the light box.

[ii] A MinoltaÔ CM-2600d spectrophotometer using CIE Lab DE*ab colorspace was used to make colorimeter measurements. The results of the colorimeter readings were evaluated in tandem with the conservator's subjective observations concerning change in colour and gloss for each test.

[iii] Hirox 3D digital microscope images were taken at Tate, London, 2016.

Practice-led and practice-based collaborative research at Tate: supporting the advancement of modern and contemporary painting conservation treatment practice

Bronwyn Ormsby

Several collaborative practice-based and practice-led applied research projects involving Tate and other key partners will be discussed. These involve treating specific conservation problems or exploring specific artist or conservation materials; all of which ideally contribute to the advancement of conservation treatment methodologies and practice for modern and contemporary paintings. Examples include the recent Rothko Conservation Project [1], current EU-funded projects such as NANORESTART [2] and the Cleaning Modern Oil Paints (CMOP) [3], as well as the ongoing collaboration between Tate, the Dow Chemical Company and the Getty Conservation Institute [4]. These projects can involve international and national collaborations between painting conservators, heritage scientists, paint chemists, as well as academic and industrial partners; many of which have been underway for several years (in some cases prior to Tate's involvement). Key aims and outcomes of these projects will be outlined, alongside reflections on research processes, as well as the ongoing challenges and successes of translating research findings into practice. References 1. http://www.tate.org.uk/about/projects/rothko-conservation-project 2. http://www.nanorestart.eu/ 3. http://www.tate.org.uk/about/projects/cleaning-modern-oil-paints 4. Ormsby, B.A., Keefe, M.H., Phenix, A., von Aderkas, E., Learner, T., Tucker, C., and Kozak, C. (2016). 'Mineral Spirits-based Microemulsions: A Novel Cleaning System for Acrylic and Other Modern Painted Surfaces'. Journal for the American Institute for Conservation. Issue 55-1, pp. 12-31.

A Preliminary Investigation into Aquazol® as an Alternative Lining Adhesive for Paintings

Blair Bailey, Raymond Aso, Richard Campbell, Ben Dawson, Nicola Grimaldi, Kallum Moses, Roger Penlington, Charis Theodorakopoulos

Reducing the energy intensity of museums, galleries and other spaces with heritage collections is increasingly important due to the high cost of fuel, and the global need to lower greenhouse gas emissions. At the front line, institutions are seeking to lower energy consumption by addressing inefficiencies related to building design, HVAC and lighting equipment, and environmental control strategies. In a parallel effort, researchers are rethinking the necessity of precise museum environment tolerances, by investigating the risk of damage to specific materials exposed to fluctuating relative humidity (RH) and temperature. The goal of this latter body of work is to define the conditions that achieve an acceptable balance between facility energy consumption and the risk of collection damage. As a contribution to this effort, a research project is currently underway at the Canadian Conservation Institute that uses acoustic emission (AE) testing to monitor, or 'listen', to model wooden structures during exposure to humidity extremes. Under conditions causing physical damage, acoustic signals are emitted by the test materials, which are subsequently detected and analysed through the AE instrumentation. One of the many challenges with optimising the museum environment is the dependence of humidity sensitivity on exposure history. It is reasonable to assume that sensitive objects exposed to RH extremes have experienced past damage, and similar repeated fluctuations will have little or no harm. This is known as the Kaiser effect in AE terminology, or the concept of 'proofed fluctuations' in the field of heritage conservation. There are, however, foreseeable exposure histories where the Kaiser effect may fail or, at least, require further attention. For example, the resetting of hide glue in wooden assemblies at high RH may lead to further damage at a repeated low RH cycle. In order to study the effects of both humidity magnitude and history, a custom environmental chamber was constructed to generate fluctuations through various control modes: square wave, sinusoidal, custom array, and cloning of an external environment through cellular communication. Samples exposed to prescribed RH conditions in this low-noise test chamber were monitored with a multi-channel AE system to detect damage. This talk will provide an overview of research work to date, with a focus on the apparatus design and ongoing experiments. Preliminary test results highlight the response of simple wooden joints and veneered assemblies, which were bonded with animal glue and exposed to cycling humidity. The findings complement other research involving AE as an early warning monitoring tool for collection damage.

Re-examining Old Findings and Inferences: The Study of a Magus at a Table by Jan Lievens

Shan Kuang

Jan Lievens and Rembrandt van Rijn were born just over a year apart, studied with the same master in Amsterdam, and maintained a close artistic relationship in Leiden from 1625 to 1632. Due to the many parallels in their early artistic practices and subject matter, even contemporaries were sometimes uncertain about the attribution of their works. It is perhaps not surprising that the attribution of a Magus at a Table (Upton House, National Trust) has been elusive. Previous attributions included Lievens, Rembrandt, and 'after Lievens.'

The painting is one of at least six versions of the same composition. In addition to the identity of the artist, the subject matter of painting is also unresolved. Perhaps the most inexplicable element of the picture is the extensive, tree-like foliage above the altar, in what would otherwise be an indoor scene. Despite the presence of pentimenti, the Upton picture was re-attributed to be a copy of a lost work by Lievens (c. 1631-2) after dendrochronology carried out in 1983 suggested a use date of 'after 1660' (a date stylistically inconsistent with Rembrandt or Lievens). Recently, however, the accuracy of this dating has been questioned; it has been suggested that the painting could be an original work.

In this study, various findings and interpretations from 1983 were re-evaluated in light of recent technical scholarship and advances in analytical techniques. This includes a re-evaluation of dendrochronological data from 1983, with further analysis carried out in 2014 by Ian Tyers. Emerging analytical and imaging technologies like macro x-ray fluorescence scanning (MA-XRF) provided key new insights into the painting's materials, construction, and relationship to the other versions.

Technical examination shed light on the numerous stages of reworking in subject matter and composition. Crucially, MA-XRF (carried out by University of Antwerp) revealed important pentimenti painted in earth, black, and copper-containing pigments, which were previously invisible in x-radiography. This paper will also reflect on how incorrect data given by dendrochronology in 1983 was able to skew the interpretation of many other technical findings. Certain old assumptions and interpretations were thus challenged in light of the new results. Aspects of the painting technique that were previously assumed to be uncharacteristic of Lievens or Rembrandt have been re-assessed in the context of the significant body of technical and historical research published on the artists since the painting was last examined. These findings allowed the Upton picture to be re-attributed as an original painting by Lievens, rather than one of the many copies after a lost work.

2018 – Research and Technical Studies Specialty Group Presentations

Big Things Come in Small Packages: The Materials Analysis Lab at Colonial Williamsburg and its Impact Throughout the Foundation

Kirsten Moffitt

Abstract

In 2014, the Conservation Department at the Colonial Williamsburg Foundation (CWF) established its first-ever Materials Analysis Laboratory to serve the needs of the Foundation's conservators, curators, architectural historians, and historic area tradespeople. Current instrumentation includes an upright microscope for cross-section and polarized light microscopy, a handheld x-ray fluorescence spectrometer (pXRF), an infrared microspectrometer coupled with a conventional light microscope, and a desktop scanning electron microscope with energy dispersive x-ray spectroscopy (SEM-EDS). The creation of this lab at CW was made possible through donor funds coupled with recent advancements in analytical technologies which have led to the development of smaller, more compact instruments with comparable sensitivities to their larger counterparts at relatively affordable prices and with more intuitive, user-friendly software. (This lecture will include a special review of the IR microspectrometer and desktop SEM-EDS for those who may be interested in the advantages and disadvantages of these smaller instruments). Most analyses are carried out by the Foundation's first-ever Materials Analyst, allowing the conservators to focus on their busy treatment schedules. However, with minimal training conservators can use instruments for their own research, as time allows. The Materials Analysis Laboratory has been a major contribution to the work of conservation staff. Case studies will illustrate some of the straight-forward ways in which having on-site analysis has been an advantage – from minimizing the time spent on empirical materials testing for the reversal of a modern glass repair, or the characterization of exhibit fabrics to assess their eligibility for dyeing. We have found, across the board, that this leads to more effective assessments, treatments, and the development of more appropriate storage environments. Another department that has embraced the lab is our historic trades program. CWF tradespeople are not simply actors – they are artisans and scholars dedicated to better understanding and mastering 18th c. tools and technologies. Collaborations between the lab with historic trades, using museum collection objects as subjects, makes CW a unique resource for material studies. Tradespeople use historically accurate materials whenever possible and they practice their craft in view of the public, providing opportunities for outreach and education relating to the role of analysis at CWF. Case studies will illustrate the variety of ways in which the lab has contributed to their work – including the study of 18th c. felt hats to identify animal fiber blends for our historic area hat-maker, to determining the color and composition of paints used on 18th and 19th c. tin lanterns in our collection that would be replicated by our tin shop for use in the historic area. As historic area tradespeople engage

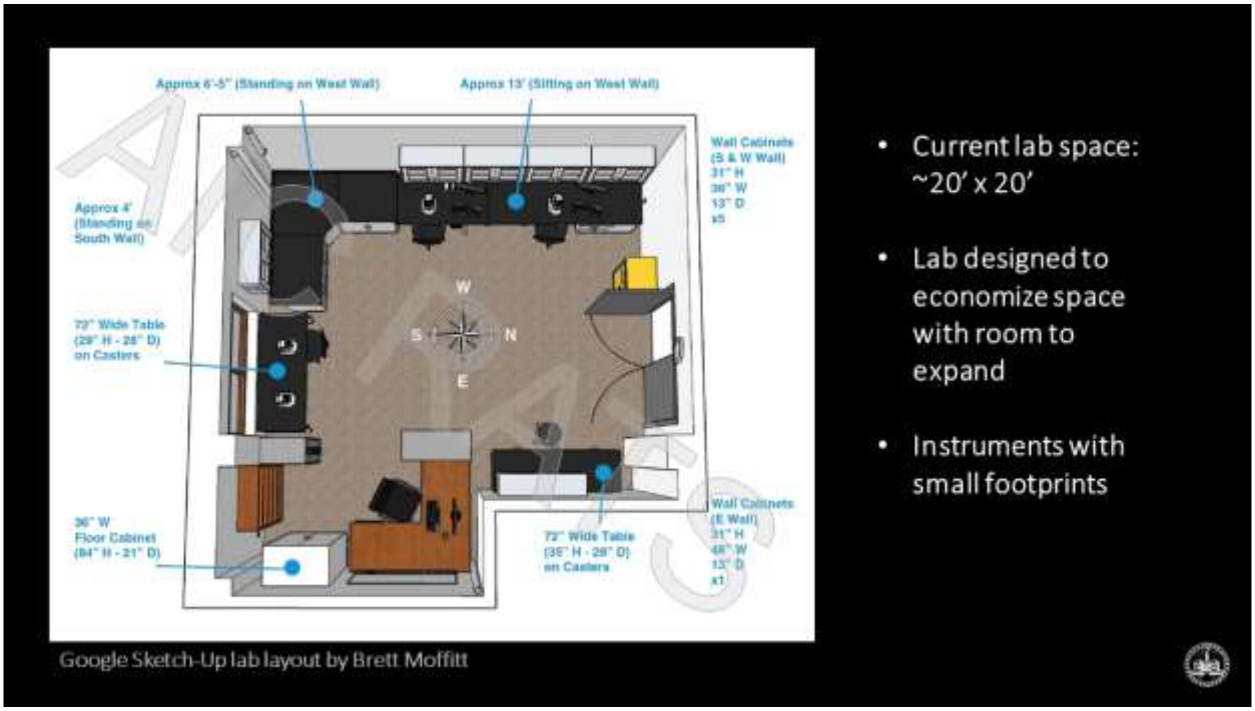
with the public, they often discuss the evidence provided by scientific analysis. This juxtaposition of modern technology within an 18th century setting gives our guests an unforgettable visitor experience and a new appreciation for the depth of our research.

Like Nancy [Odegaard], I will also be exploring the role that conservation science plays in our understanding of material culture, but I'll be focusing on its impact at our specific institution – the Colonial Williamsburg Foundation -- and how our recently established analytical lab has impacted our Curatorial, Conservation, and Historic Trades departments.

My main title is Big Things Come in Small Packages, as I will first discuss our lab and some of our specific instruments - many of which are on a smaller scale and accordingly, at a lower price point- including a compact FTIR microspectrometer and desktop SEM.

Since establishing the lab I've been getting a lot of questions from colleagues who, like us, are looking to expand their analytical capabilities with instruments that can be operated by conservators, not just by conservation scientists, so I thought this session was also a good opportunity to share some useful information.

You might notice my title is Conservator and Materials Analyst – I am trained as a conservator but I did a lot of analysis in graduate school and actually started at CW as an architectural paint analyst. But like most of my colleagues I wear many hats- I now balance treatment duties with analysis, although I do much more analysis as our lab continues to grow.

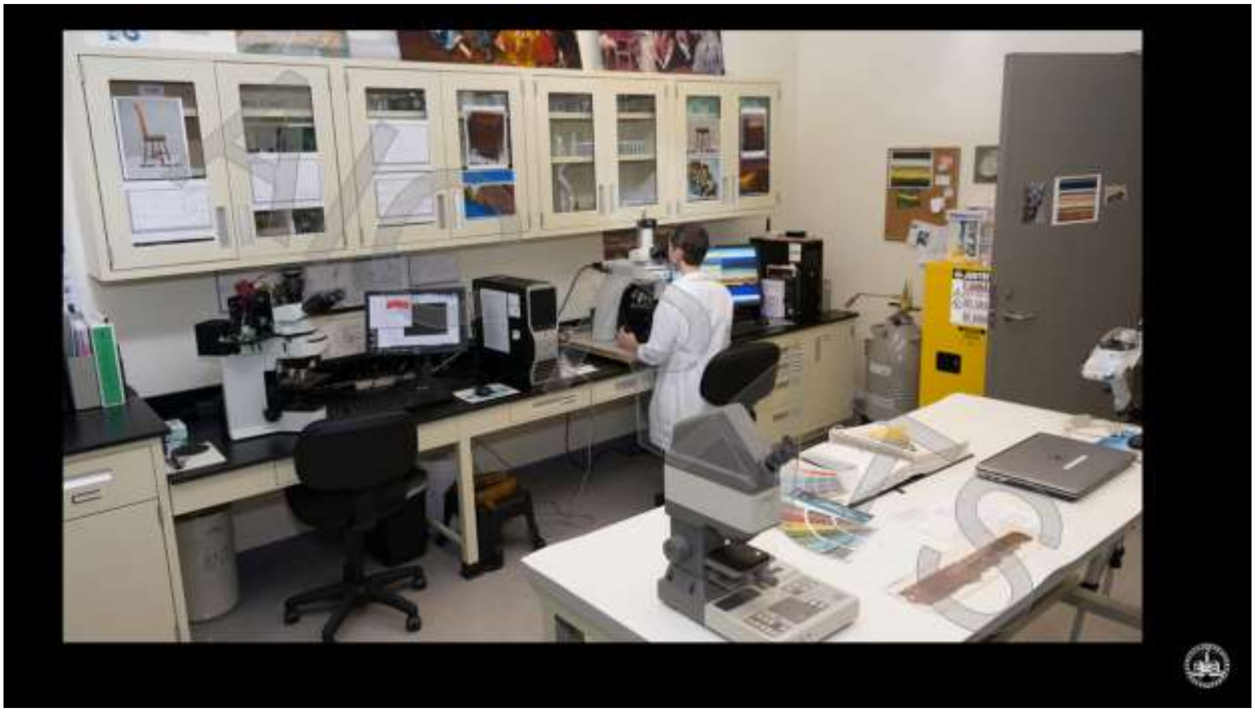


Although the Analytical Lab was formally established in 2014, the Conservation department was actively conducting research long before then. We were doing technical imaging with X-rays and IR, and microscopy and some chemical testing, but of course, more advanced instrumental research was only possible through partnerships with other institutions or by sending samples to outside labs for analysis.

For a long time, CW conservators keenly felt the need for on-site analytical capabilities to assist in their treatments and answer research questions, and in 2007, thanks to some terrific donors (everything in the lab is donor-funded), the departmentt acquired its handheld Bruker Tracer XRF, and in 2009 we acquired our Smiths Detection FT-IR microspectrometer. This was a great move forward for inorganic and organic analysis (and before my time at CW, I started there as a graduate fellow in 2010), but from what I understand the disadvantage was that in addition to their busy treatment schedules, conservators often did not have the time to regularly use the instruments and keep up with their maintenance and upgrades, receive training, not to mention fielding non-conservation related requests from other departments. So while we had the equipment, we didn't have the resources to use them to their full potential.

So the establishment of a central analytical lab managed by a single person to serve the department became an important goal for our then-Director of Conservation, David Blanchfield. And the lab that we have today is the result of his vision. I became part of this vision because by that time I was already at the Foundation carrying out architectural paint research in an off-site microscopy lab, but sometimes using the XRF and FTIR in the conservation department. The donors had again provided the funds to purchase a new instrument, this time a fluorescence and polarizing light microscope, and David got me involved to help spec out the system.

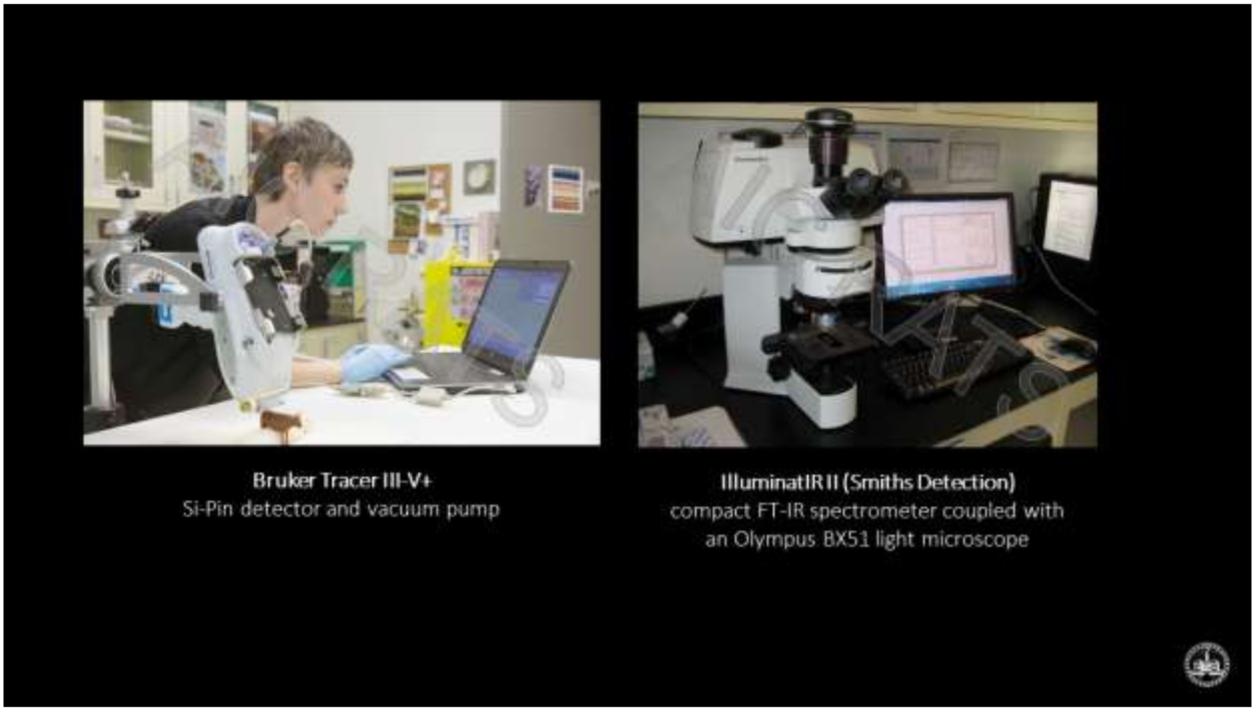
The current lab is the smallest lab in our department, measuring approx. 20' x 20'. When designing the space we were careful to leave room to grow (because the donors had hinted at additional gifts). Therefore, having a handheld XRF and a compact FTIR microspectrometer at this stage really helped us make the most of our available space.



This is the lab today, located in the Bruton Heights Wallace complex just outside CWF's Historic Area.

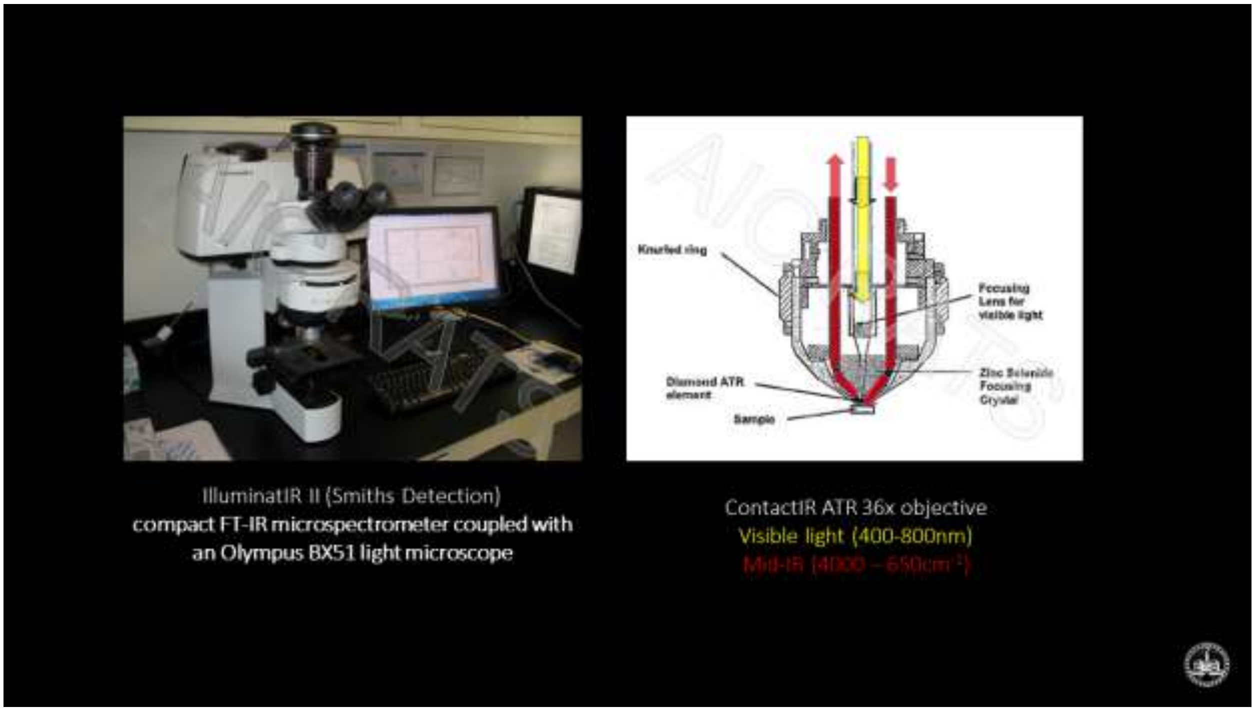
Beyond physically setting up the lab, there were other things to establish: prioritizing analysis requests, establishing a system for sample storage, and creating analysis report templates that follow AIC guidelines. I don't have time to discuss these today, but I am happy to share our system with anyone interested.

I do want to note that while I manage the lab and take on most of the analytical requests, I am not the only person who does analysis. All of the equipment is available to conservators as long as they are trained and feel comfortable using the instrument. But if they are a little rusty or need assistance with interpretation, I am right there to help.



Our XRF is a handheld Bruker Tracer III-V+ with an energy dispersive spectrometer and a Silicon pin detector. Where necessary we use the vacuum pump to detect lower atomic number elements, the lowest being Magnesium. I know many institutions have this same or similar instrumentation so I'm not going to go into any more detail regarding this instrument.

But I will take a moment to describe our FTIR system.



What you are looking at here is our Smiths Detection IlluminatIR II infrared microspectrometer, which measures approx. 16" (W) x 7" (H) x 5" (D) (just about the size of a shoebox), and is mounted on the frame of an Olympus BX51 light microscope. It uses an MCT (mercury cadmium telluride) detector (more appropriate for smaller spot sizes, must be cooled with liquid nitrogen), and analysis is done in the mid-IR range (4000-650cm-1).

With this system, we can perform FT-IR analysis but still retain all of the optical/analytical capabilities of a conventional light microscope such as polarizing light microscopy and reflected light microscopy, and we are left with the same footprint as a light microscope (as opposed to a specialized IR microscope that interfaces that to a laboratory FT-IR bench, which takes up far more space).

We have a reflectance objective but we primarily use the diamond ATR objective which makes contact with the sample. Its design is unique – it is called a "see through" ATR, meaning that it is both an optical AND an analytical objective. It is designed so that you can see the sample at the same time you are collecting your data. As shown this schematic, The IR beam (red) passes through the front and back of the objective while the optical light path (yellow) goes through the center. Being able to see my sample helps me refine the target area. For example, if I have a sample of green paint I can focus on the blue particles and then the yellows using the same objective.

I have also been able to use this objective successfully on paint cross-sections mounted in resin.

I would say its disadvantages have nothing to do with the instrument, but there are limitations with the software. It only runs on Windows7 32 bit, which has been a real headache with our IT department. And Smiths Detection no longer manufactures this instrument so they have outsourced their support (although we work with an independent contractor who used to work with Smiths Detection and he has been terrific). We use OMNIC for spectral processing and database management.

This is our Nikon Ni-U epifluorescence and polarizing light microscope with a pixel-shifting camera which we use for cross-section microscopy as well as pigment and fiber ID. The cross-section shown at right was taken from one of our historic buildings, the Robert Carter House.

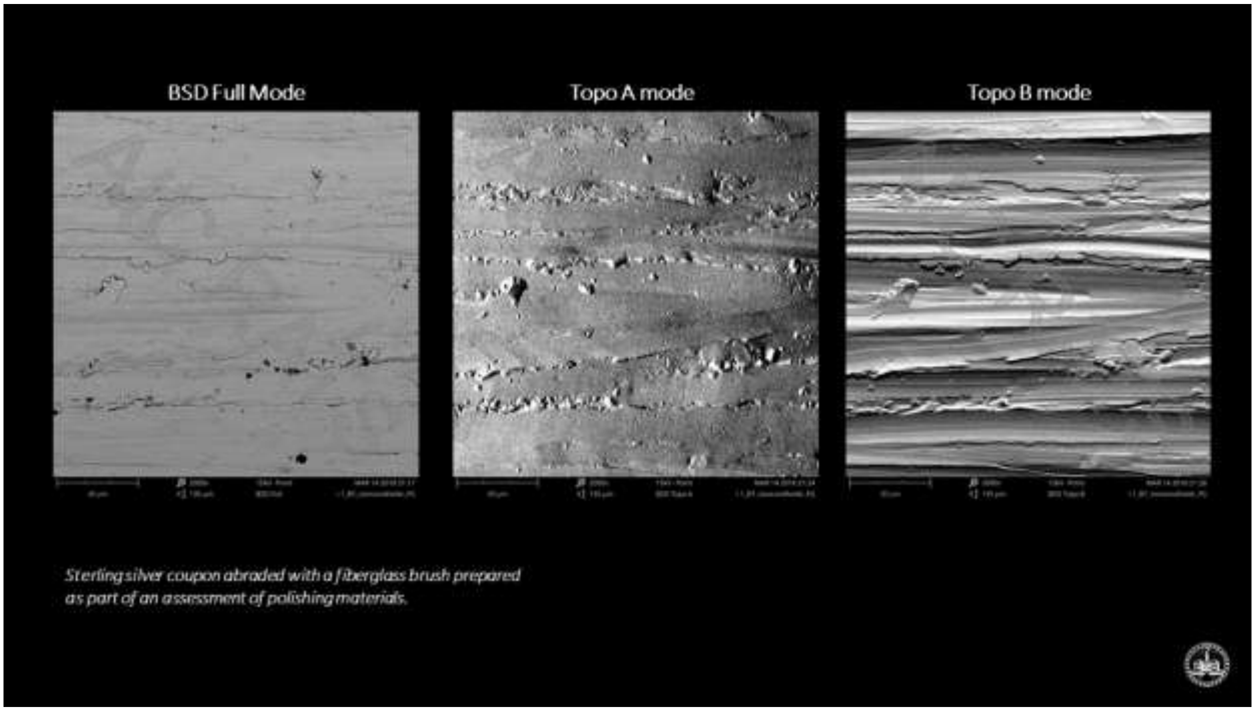
I think the most important piece of lab equipment is our microscope. I often find that all of my projects start and end with microscopy, as there is just so much one can assess through observation that even the instruments won't pick up. Plus, one a personal level, having the analytical capabilities to confirm or disprove my own visual characterizations has really helped hone my microscopy skills. I teach PLM to the first-year conservation students and Winterthur and I always urge them to do the same, because I keep reminding them- that they may not end up at an institution or studio with an analytical lab. A used PLM is much less expensive than an XRF.

In 2016, thanks to our donors, we acquired a Phenom Pro-X desktop scanning electron microscope made by a company called Nanoscience. They are based in the Netherlands but have satellite offices in Phoenix and, conveniently for us, Alexandria Virginia. We looked at a few other desktop SEM systems but the Phenom was the best fit for us. It was within the price range our donors were comfortable with, had the smallest footprint yet the best resolution (of other desktop systems we had tried), the sample prep was minimal and the software was incredibly easy to use. In the image above, the SEM-EDS is the instrument on the left, and the monitor in the middle controls the SEM, while the monitor on the right controls the EDS.

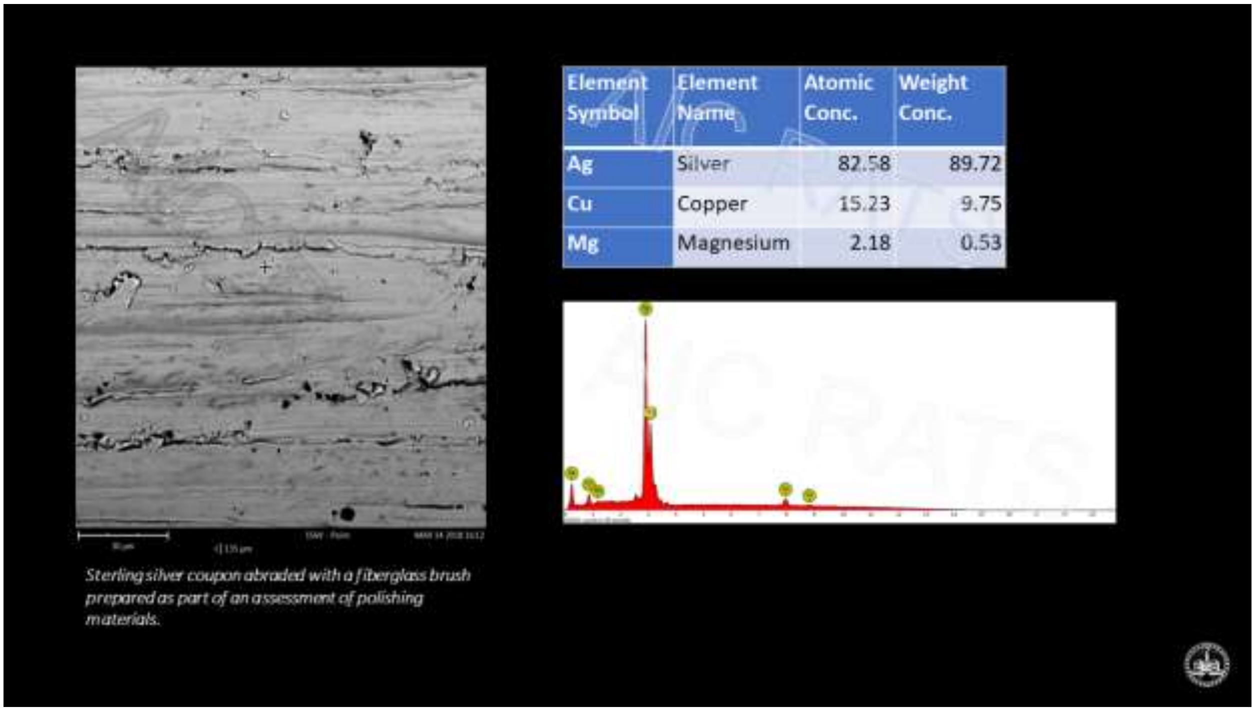
The electron source is Cesium Hexaboride or CeB6, which is 10x brighter and can last up to 30x longer than your typical Tungsten source. And there is no catastrophic failure with CeB6, it degrades gradually so you have time to schedule replacement rather than have your source fail and your system suddenly becomes unusable. We've been using our system for 3 years now and recently had scheduled preventive maintenance and the rep said our source is in great shape and should last 3 more years.

This is the Phenom system in our lab. Sample prep is minimal. Samples mounted onto a stub with double-sided carbon adhesive pads and placed into one of two sample holders – one for conductive and one for non-conductive samples.

No coating is required (although the company does sell a sputter coater separately). That's it. The cup is simply placed into the sample chamber like so and you can image it in about 30 seconds. Once the cup goes into the system it is mated to the end of the electron column; since it becomes one unit with the SEM chamber we have great vibrational stability that is not affected by outside movement (this was a concern for us, because our air handler systems can sometimes cause vibrations that are apparent when I use the 1000x objective on the optical microscope).



There is no secondary electron detector (SED) but the backscatter detector (BSD) has four quadrants. In “Full Mode” all four quadrants are receiving information. This is your typical BSE image. Topographic information can be gathered using was is known as TopoA and TopoB mode, in which half the detectors are turned off, so only the detectors on the right or left side are receiving information. in essence it is like a raking light image using electrons.

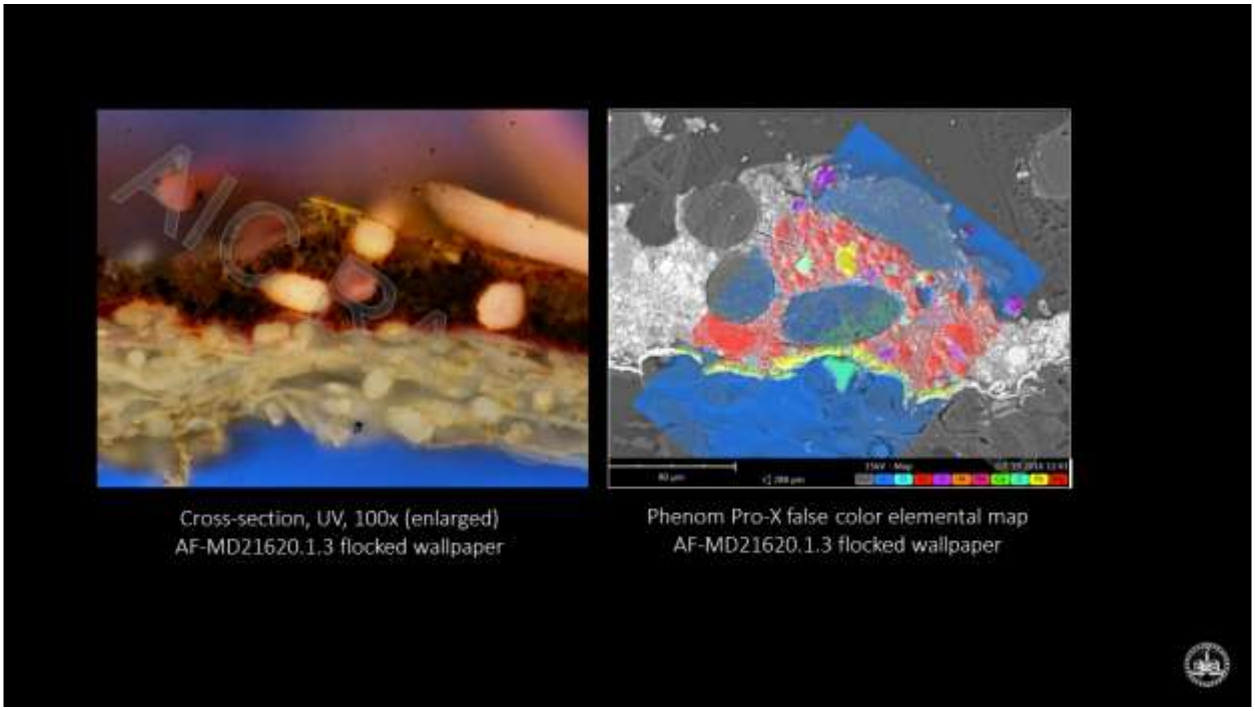


Element Symbol	Element Name	Atomic Conc.	Weight Conc.
Ag	Silver	82.58	89.72
Cu	Copper	15.23	9.75
Mg	Magnesium	2.18	0.53

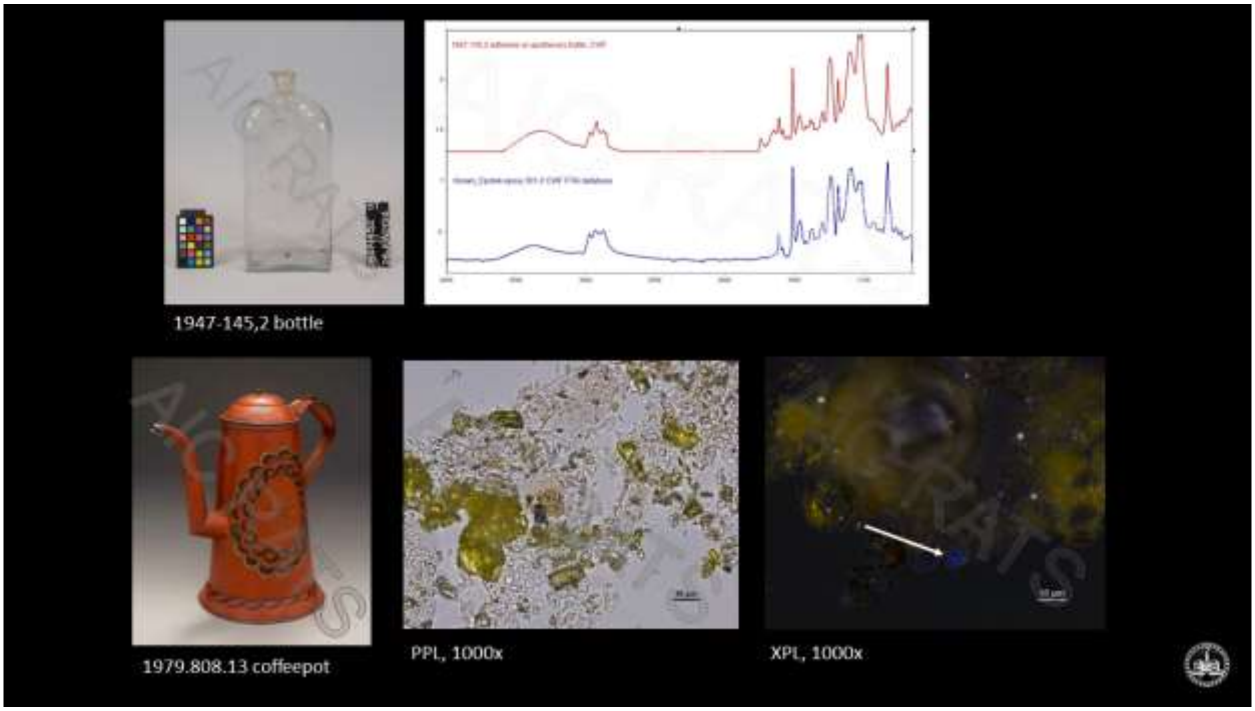
The available accelerating voltages are 5, 10, and 15kV

The beam current settings can be adjusted for for imaging, point analysis, and mapping.

The "point" analysis mode generates our spectrum and and also gives atomic and weight concentrations (although in my experience these are not accurate, more semi-quantitative), but can be a helpful way of evaluating data in certain situations.



Line Scanning and Mapping capabilities are available with the EDS software. I do a lot of cross-section analysis of layered surfaces so the mapping is a feature I use frequently. One can do a 'quick and dirty' 5 minute map or leave it to map overnight, depending on how high resolution you need your final image to be.

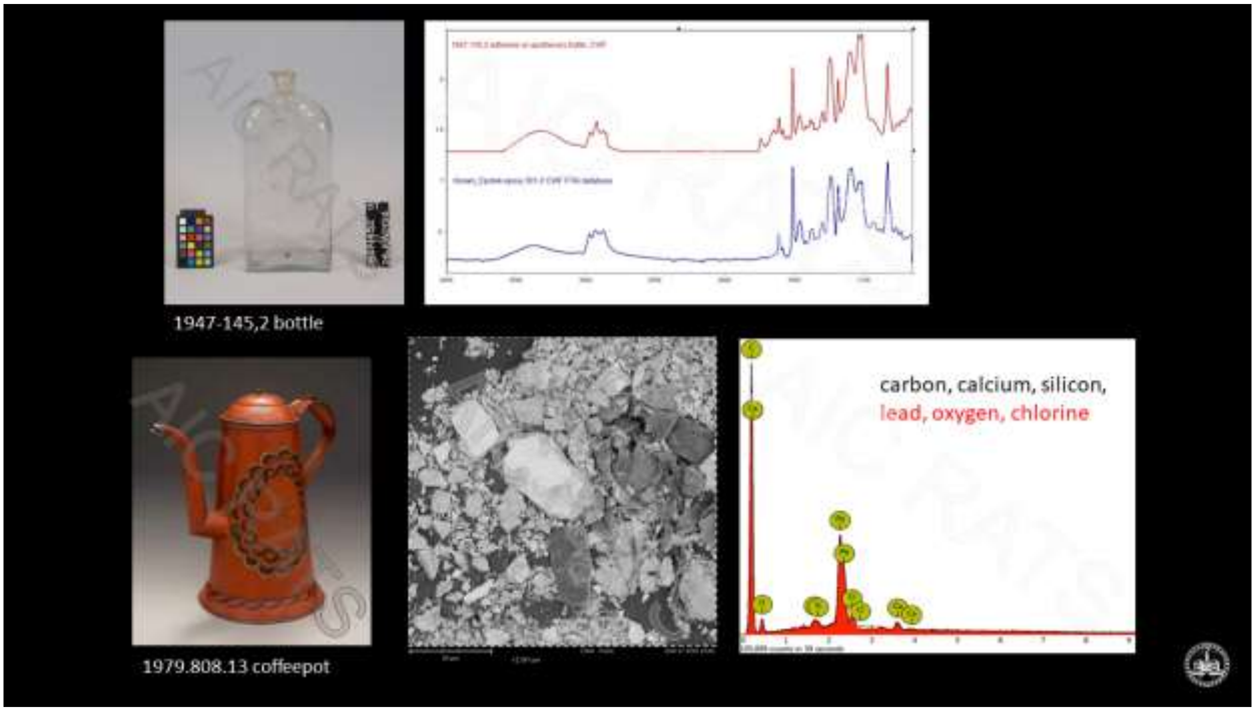


Every analytical project is a collaboration between myself and the conservator, curator and/or historic tradesperson because we all bring different things to the table. However, the primary purpose of the lab is to SERVE our various departments. So, we are a service lab and as such I do try and get results to the requestors as soon as possible.

This glass bottle is a very typical example of a straightforward, top priority project: the failed and yellowed adhesive at the lip of the bottle was not responding to typical chemical removal methods and so a sample was brought to me for analysis and FTIR quickly determined that it was an epoxy.

In addition, I often work with the curators to carry out technical analyses of objects for exhibition. Working with our metals curator I carried out a technical analysis of the pigments found on this tinned-iron coffeepot, to help narrow down the date of the object and to provide additional information for the exhibit label. Pigments identified included vermilion, Prussian blue and lead white. There was a brownish paint that we initially assumed was an oxidized bronze paint, but XRF detected no copper or zinc, only lead. I examined some extracted particles with PLM and observed very coarse lemon-yellow colored particles with very high relief that in XPL (cross-polarized light) displayed a deep purple-blue interference color.

This is not a pigment I came across often, but after some research I was quite sure this was a pigment called Patent yellow, also called "Turners Yellow", a lead oxychloride that was patented in 1781 but superceded by the introduction of chrome yellow pigment in the early 19th c.

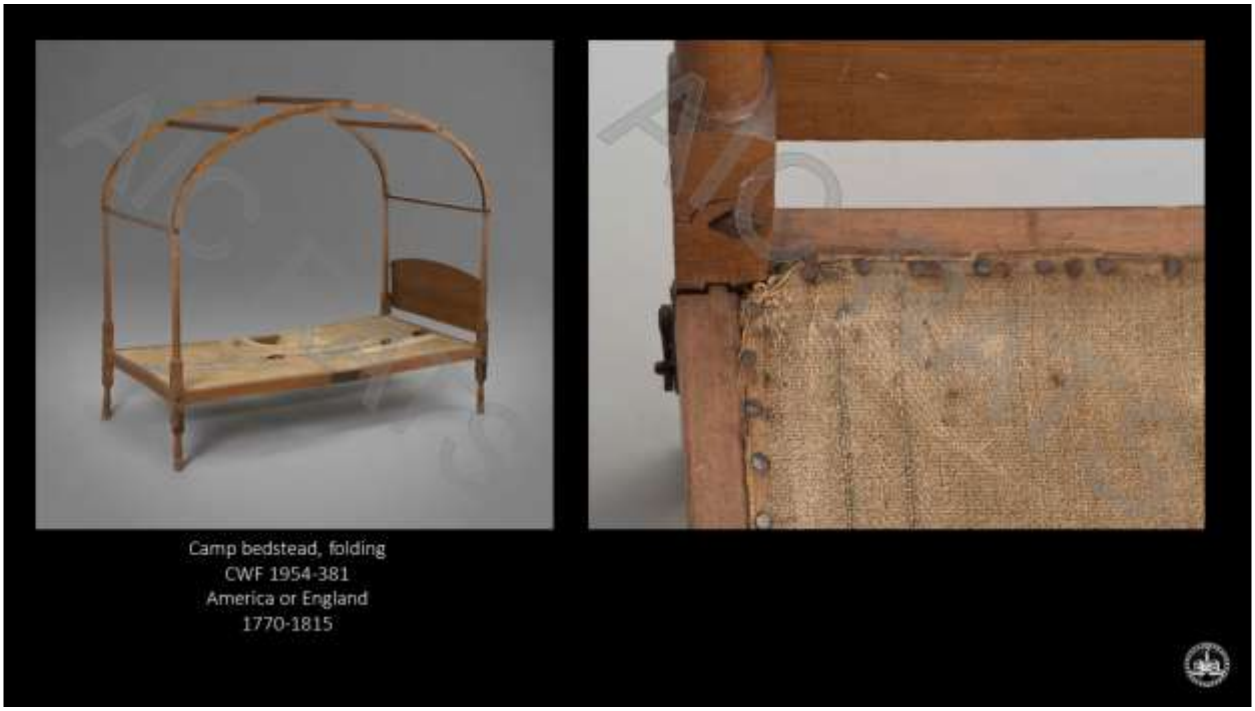


SEM-EDS was able to detect chlorine in a sample of the yellow pigment, which confirmed that this was indeed Patent yellow. Since this pigment was reported as being used primarily between 1790-1820, this helped us narrow down a date for the object. I was encouraged when, some time later, I visited this exhibit and saw that a description of the analytical results had made its way into the exhibit label. We are finding that, more than ever, the public wants to know “how we know what we know”.

While the relationship between the lab and the museum-related departments may be typical for many institutions, CW has a unique resource – our Historic Trades Program - that has collaborated with the lab and we see the benefits in the historic area.

We have nearly one hundred masters, journeymen, journeywomen and apprentices practicing more than thirty 18th century trades including tailoring, gunsmithing, shoemaking, weaving and dyeing, printing, bookbinding, and blacksmithing. Some of these trades survive only because of the foundation's dedication to preserving these skills. The tradespeople are not actors- they are professional, full-time artisans dedicated to their specific profession and practicing it publicly, sharing their knowledge with our guests.

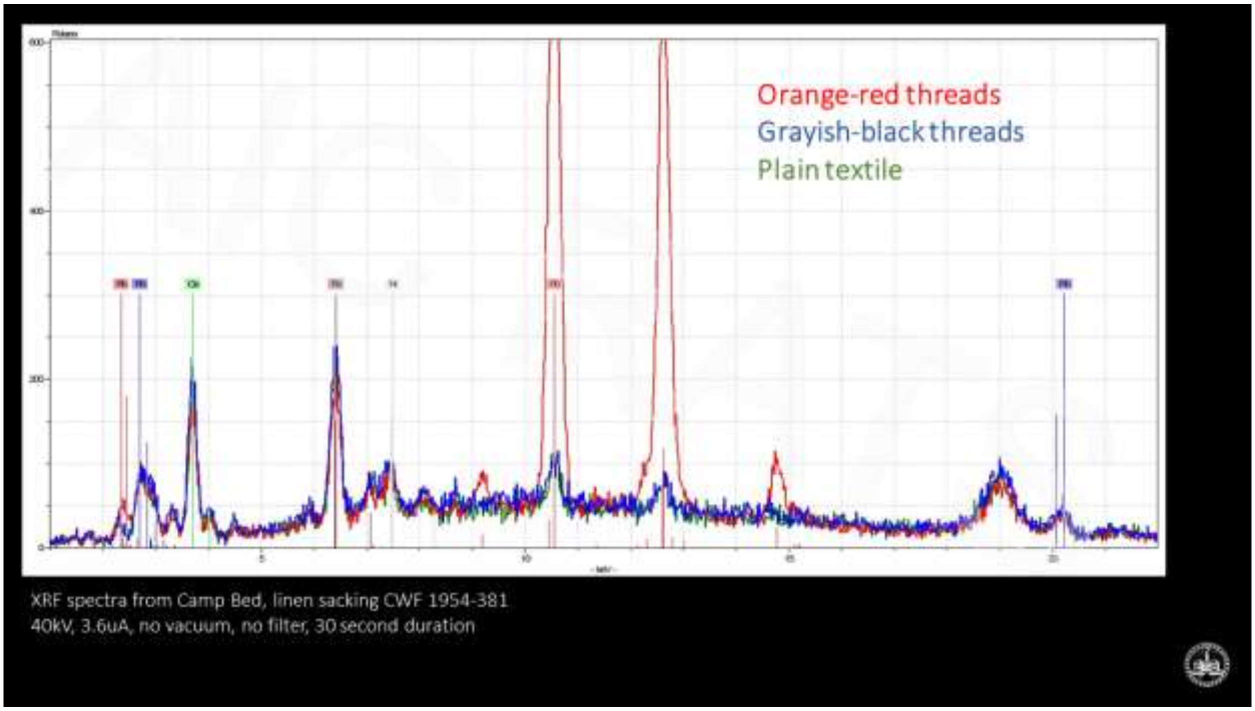
The lab sometimes impacts them, their work and the materials they use, which I will illustrate in this next section. Since the trades are always on view to the public, this creates a direct route for our visitors to learn about the analytical research that goes into every detail they see in the historic area.



One example of this collaboration is the Camp Bed Project.

The camp bed you see pictured here from our collection was planned to be reproduced by Historic Trades for the Museum of the American Revolution in Philadelphia. As the craftspeople and curators were examining the details of the bed, they noticed the faint colored pin stripes on the flax (coarse linen) sacking.

I was called in to examine the stripes and identify the colorant. Of course, I initially thought this was a dye and I explained that we didn't have the instrumentation to identify dyes, but looking closer I noticed that the yarns weren't dyed, but rather, appeared to have been painted.

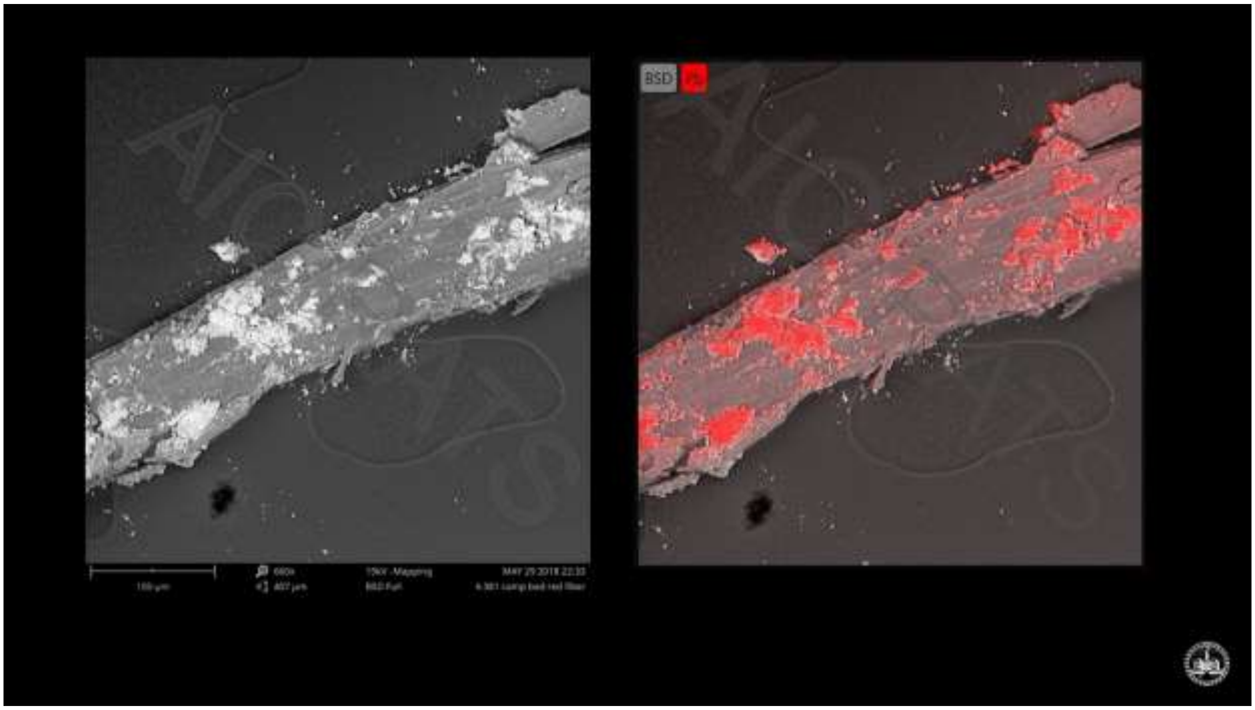


XRF determined that the light orange-red stripes contained a great deal of lead.

XRF could not detect any additional elements in the grayish-black stripes that were not in the uncolored areas.

Closer examination and microscopy of extracted samples determined that the threads were indeed encrusted with pigment, they had most certainly been painted. Furthermore, they had been painted BEFORE they had been woven together, the color was not simply stamped on top (we do have a number of printed textiles in our collection that were printed using blocks of colored paint, but this was not the same process).

Viewing the orange-red pigments in cross-polarized light, I clearly observed the distinctive greenish-interference colors of red lead, but I saw no other pigments present. This was just a pure red lead.



FTIR suggested the paint was bound with a drying oil.

Shown at the above right is the false-color elemental map showing the distribution of lead.

Through analysis we identified the materials and an idea of the the process used to create the colored stripes in the sacking, but the next step was actually putting these unexpected findings into practice and seeing how well it would work with the resources available at the Weavers and Dyers shop

When we need small-batch hand-ground paints for historic area projects, we use Alan Mitchell, who I will introduce you to in a few slides. But Alan was one of our craftspeople who hand ground all of the paints used in these examples, using a muller and slab, in view of the public.

One thing we did know right away was they the craftspeople would not use red lead pigment for obvious reasons, so an iron oxide red was chosen. This was, of course, a compromise but a necessary one. Lamp black pigment was used for the black stripes. The pigments were mixed with linseed oil and after some experimentation, it was found that the paint needed to be very runny to deeply impregnate the fibers.

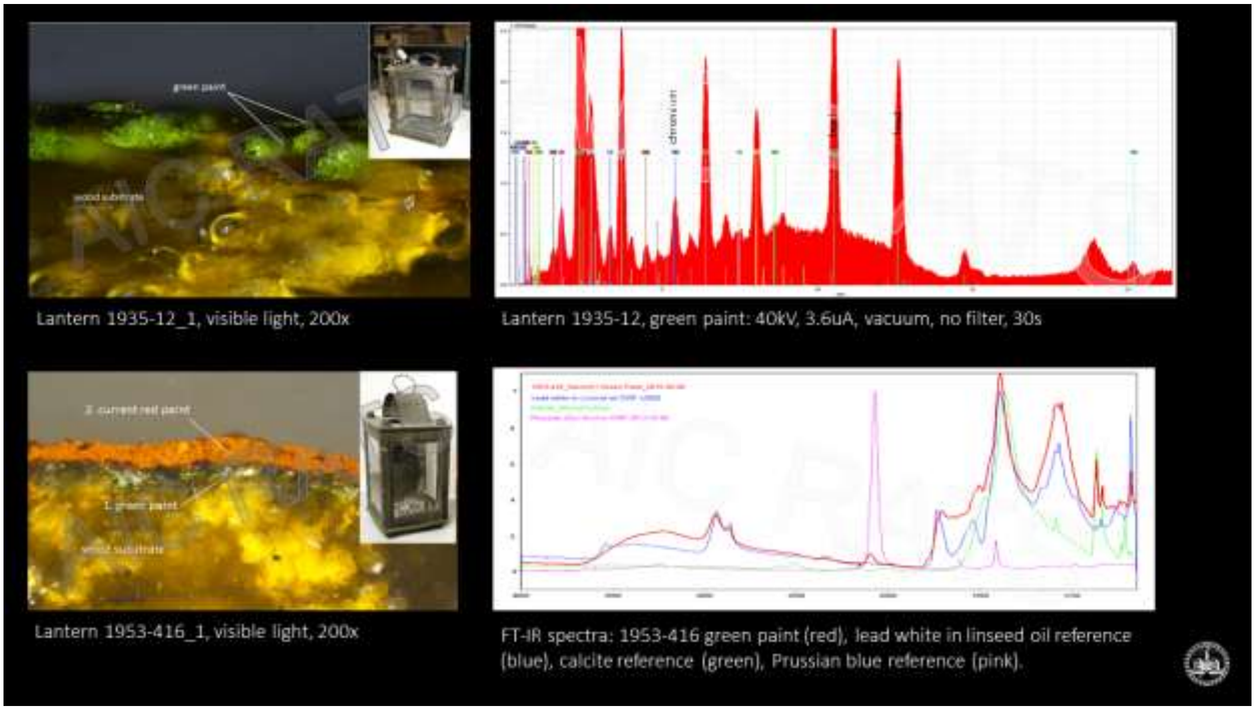
In the above left image, you see the apprentices painting the yarns before weaving. Of course this is being carried out in front of our visitors, and it wasn't exactly what one would expect to see at the Dyers shop- but this became a perfect opportunity to talk about how we collaborate behind the scenes to create accurate replications. Sometimes the results aren't what we expect, but this is how we learn.

One the yarns had dried they were set up on the loom. A light-colored piece of canvas was laid underneath the loom to see if and how much pigment would flake off. The weavers fully expected a lot of pigment to flake, but they reported that there was almost no loss and the yarns were surprisingly flexible and easy to work with during weaving.

Why did they use paint instead of dye? That is the question we still can't answer – neither the curators nor the tradespeople have come across any mention of this in the treatises, but they assume it was a case of limited resources and using what was available.

Another project involving historic trades took place in 2015 when, after years of preparatory research, the Foundation's architectural historians and craftspeople reconstructed the Market House in the historic area. The tinsmith's shop was asked to produce period-appropriate replications of lanterns for the structure. Stylistically, the tinsmiths had plenty of source material in our collection. But the analytical lab became involved when the question arose: what color would the lanterns have been painted? And what would have been the composition of this paint?

Working with the curators, a number of painted lanterns were pulled from our collection that were thought to date from the appropriate time period. These would form the basis of our research.



The results showed that almost all of the lanterns had originally been painted green, but in all but one of the lanterns, the green paint contained chrome yellow pigment, which was not introduced until the early 19th c. Since we were looking for an 18th century paint formulation, this was not helpful. It also caused the curator to have to re-assign the dates of the lanterns, since most were thought to date to the 18th c when they were acquired (note: we are aware that just because the paint is early, doesn't mean it is first period. That is a whole other conversation).

One lantern did contain an early green paint with a composition consistent with the 18th c.

Lantern 1953-416 contained two layers of paint – the current red and beneath that a green. I did PLM first to characterize the components and found Prussian blue, lead white, chalk, and a yellow iron oxide. FTIR was able to confirm all of these pigments with the exception of the iron oxide, which cannot be detected with FTIR. The binding medium appeared to be an oil but it was difficult to extract enough media for confident analysis. In addition, this layer was so compromised that getting a good color match was not possible (we do have a Minolta microscope/colorimeter that can obtain readings from 0.3mm, but there was not even enough material for this).

However, this data was enough to go on. Alan Mitchell took the components that I identified through analysis and did some experimentation. He worked with the tinsmiths and the architectural historians (who designed the markethouse based on exhaustive research) to come up with a color and finish that they could all agree on.

He did use the same pigments, but he found that the linseed oil did not dry well on the tin, so he switched to a fast-drying copal varnish, which had a glossier sheen that everyone was happier with. Alan reported that grinding the pigments into varnish was not so different from grinding in oil, but that it needed to be applied in multiple layers (at least two) to prevent streaking. A final glaze of copal varnish lightly pigmented with the same green served as the final topcoat.

Here you can see the market house with some of the lanterns visible (annotated with arrows). It has been three years and the lanterns and their painted surfaces are still all in excellent shape.

This is Alan Mitchell. Alan was our historic area paintmaker (he recently retired).

Alan was located in the wheelwright's shop, and one could always walk past and see him grinding paint for a newly-made wheelbarrow or ox-cart.

I loved stopping by to visit whenever I was in the Historic Area to see what he was working on. Here we are "nerding out" over some paint he was making using a red ochre he dug up and processed from North Carolina. He was a great resource for me, as I had a never-ending source of hand-ground mock-ups to use as references. And Alan was always, always interested to know about what I had been finding in the lab and how he could incorporate that into his work.

Visitors really responded positively to Alan's demonstrations. He told me some would come just to see him and grind paint. And Alan, in addition to explaining the process to the public, always talked about how what he was doing was influenced by the findings of the analytical lab. So again, in this way, everything comes full circle- although visitors are immersed in the 18th century they are still getting an idea of the role analysis plays at the institution.

Thank you for your attention.

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A Collaborative Study of Sari Dienes' Plaster Works

Ainslie Harrison, Annette Fritsch

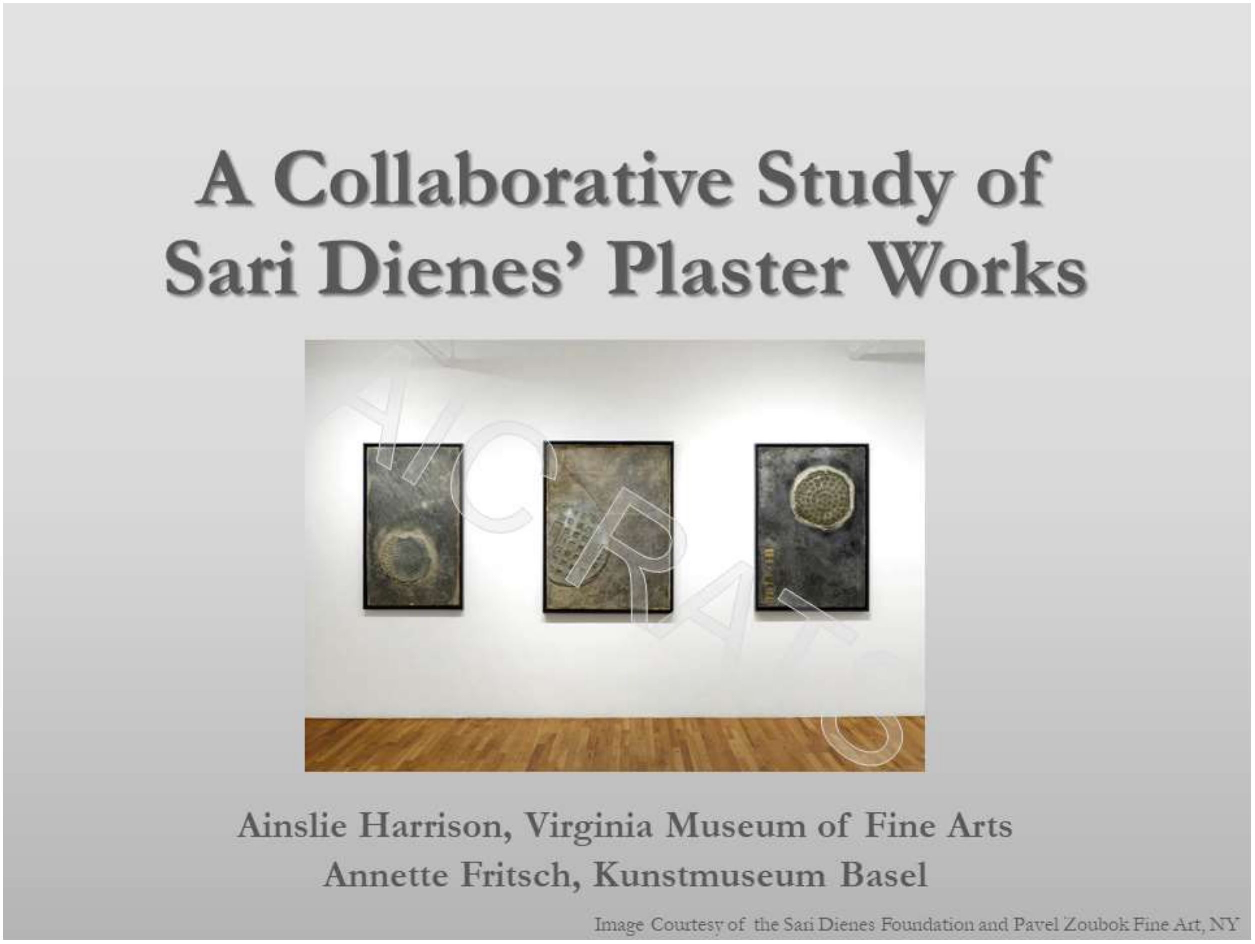
Abstract

Sari Dienes, a highly innovative 20th century female artist working in a range of media, has gone largely unrecognized until recently despite the documented influence she had on her male contemporaries including Robert Rauschenberg and Jasper Johns. Since the recent re-discovery of her impact on the 20th century art scene, museums and collectors have begun to acquire her artwork, including a series of mixed-media pieces utilizing plaster casts of manhole covers. In 2016, the Kunstmuseum Basel purchased Snowflake Circle, while the Virginia Museum of Fine Arts (VMFA) acquired Star Circle, with the goal of finally exhibiting this important yet overlooked artist's work.

As Dienes' sculptures had not been previously studied, her materials and techniques were almost entirely unknown. Preparation of these artworks for exhibition provided the first ever opportunity to carry out a technical study of Dienes' plaster cast assemblage pieces. Without published research to refer to, conservators at the Kunstmuseum Basel proposed a collaboration with the VMFA to share information gathered from the study of each of their two works. Conservators at each institution examined their respective artworks and performed a range of analyses including FTIR, XRF, UV imaging, X-Radiography, and microscopy. A broken manhole cover cast from the same series that was housed in the archives of the Sari Dienes' foundation was also examined. The information gathered from this collaborative study was used to inform two key questions: 1) How do Dienes' plaster casts fit into a greater art historical context? And 2) How to stabilize these two artworks for exhibition?

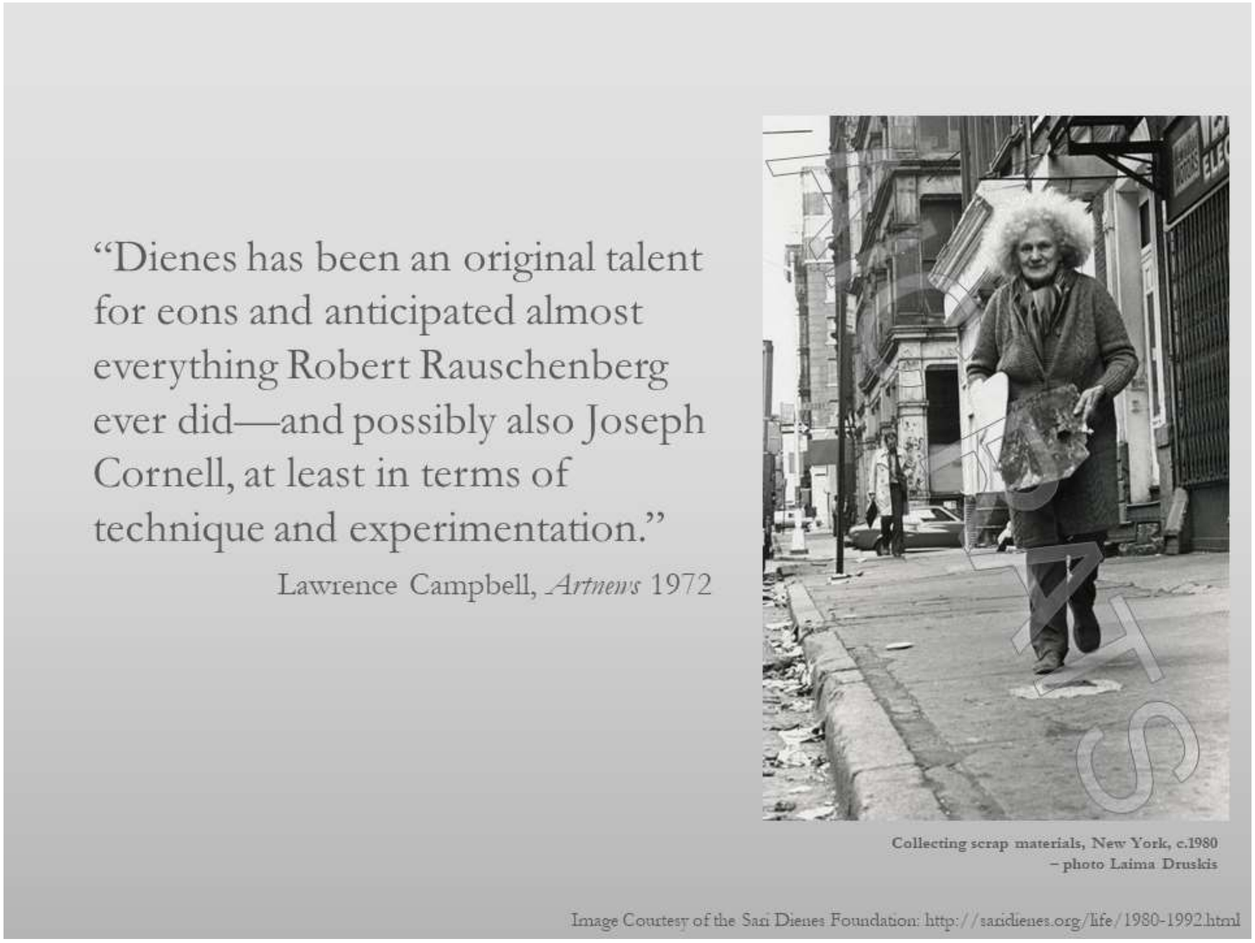
While both museums were eager to install their newly acquired Dienes artworks, examination of Star Circle and Snowflake Circle after removal of their gallery frames revealed a range of condition issues affecting their stability, including a bowing polystyrene foam board support and flaking plaster. The collaborative research project guided the stabilization efforts with the goal of finally presenting these works in the museum next to the male artists she inspired.

In addition to aiding in the stabilization of the two artworks, this research also informed the curatorial question regarding the role Dienes played in the adoption of plaster casts as a component in mixed media artworks. Materials analysis and archival research offered new insight into the possible chronology for Dienes' plaster cast assemblage works, thus helping to elucidate her role in the history of art.

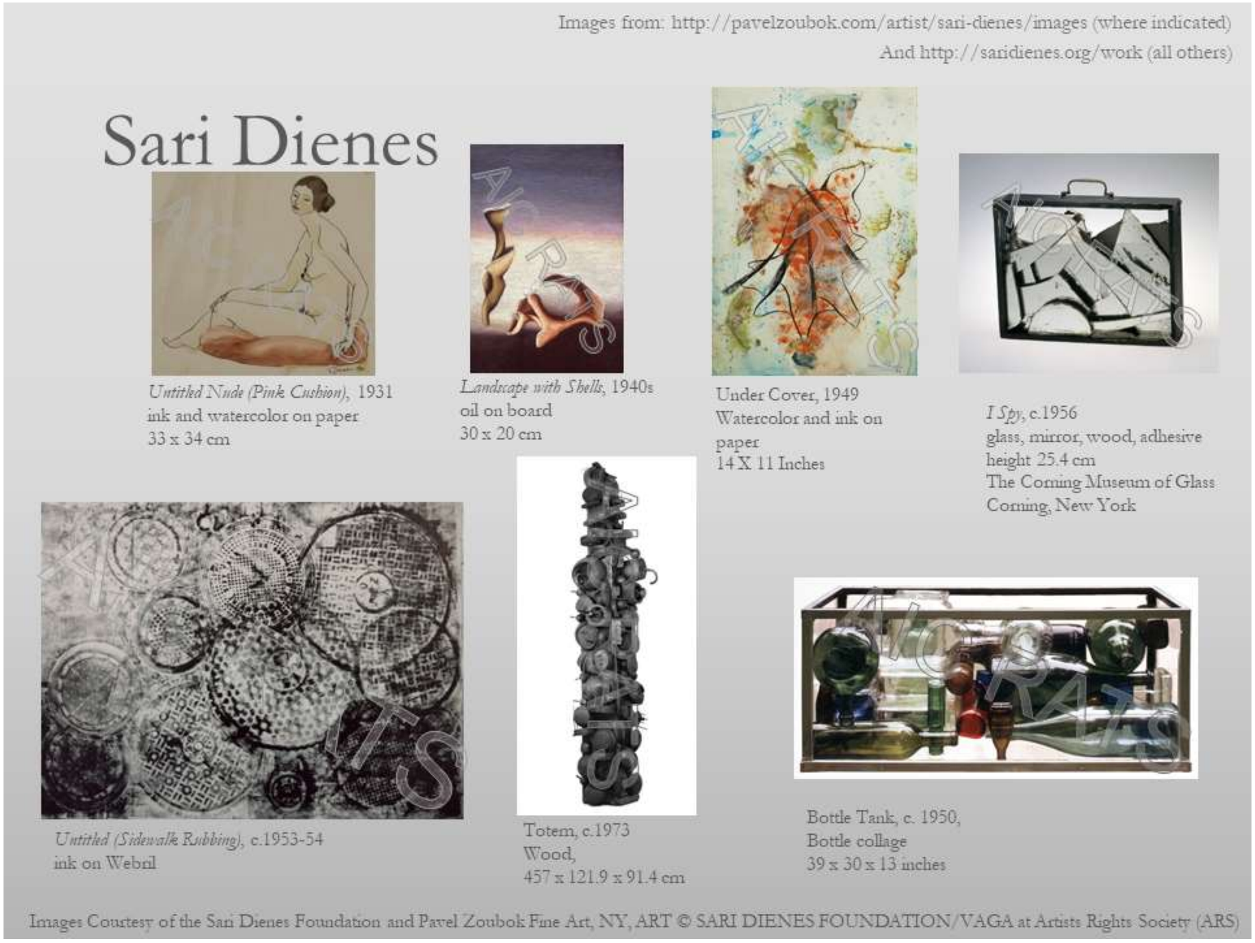


Presentation given in the June 2, 2018 Research and Technical Studies Session at the 46th Annual American Institute for Conservation Meeting in Houston, TX

While she has not received the same renown as her male contemporaries, Sari Dienes, was an incredibly influential innovator in the New York art world since arriving in the US at the outbreak of World War II.



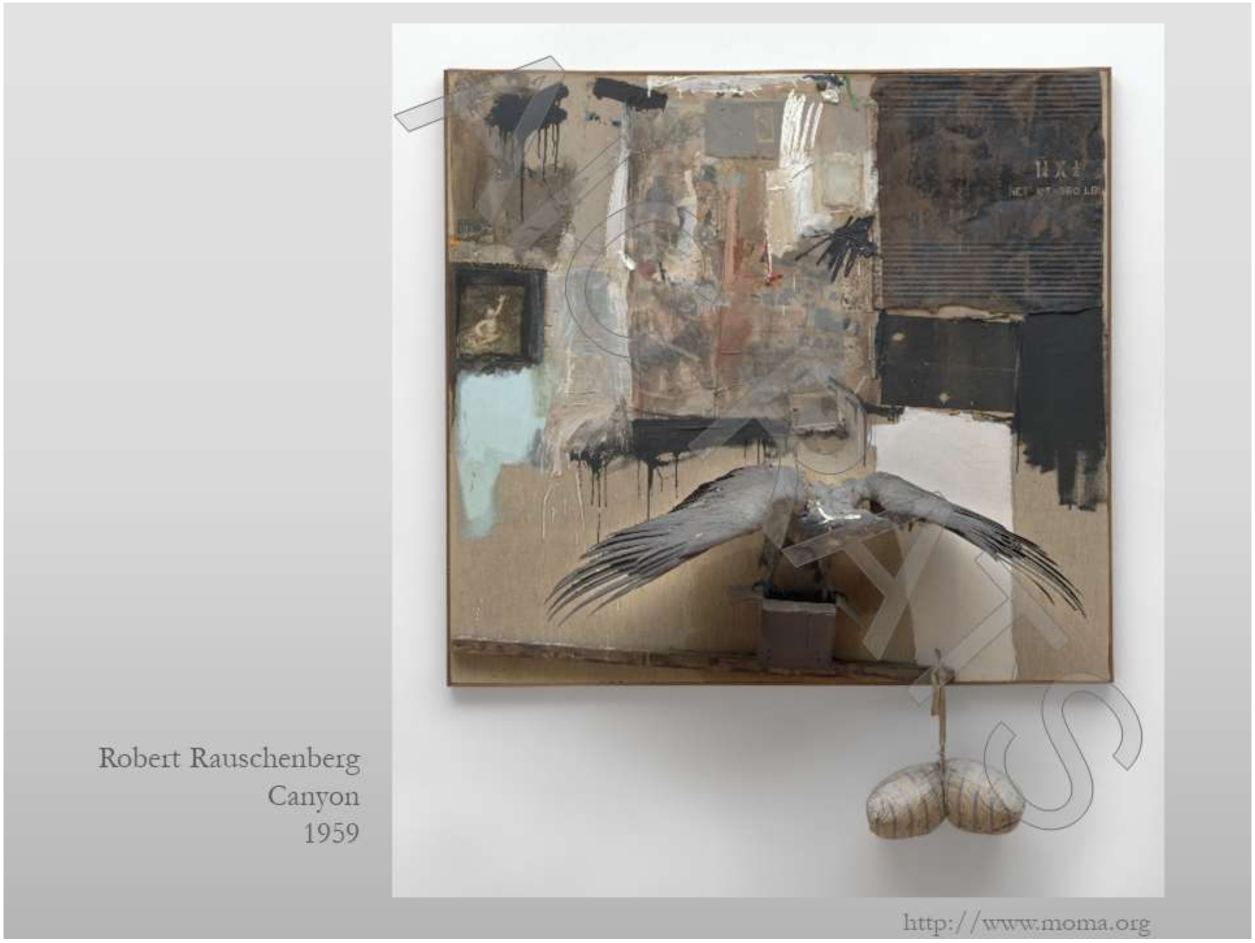
As Lawrence Campbell wrote in a 1972 article in Artnews: "Dienes has been an original talent for eons and anticipated almost everything Robert Rauschenberg ever did—and possibly also Joseph Cornell, at least in terms of technique and experimentation."



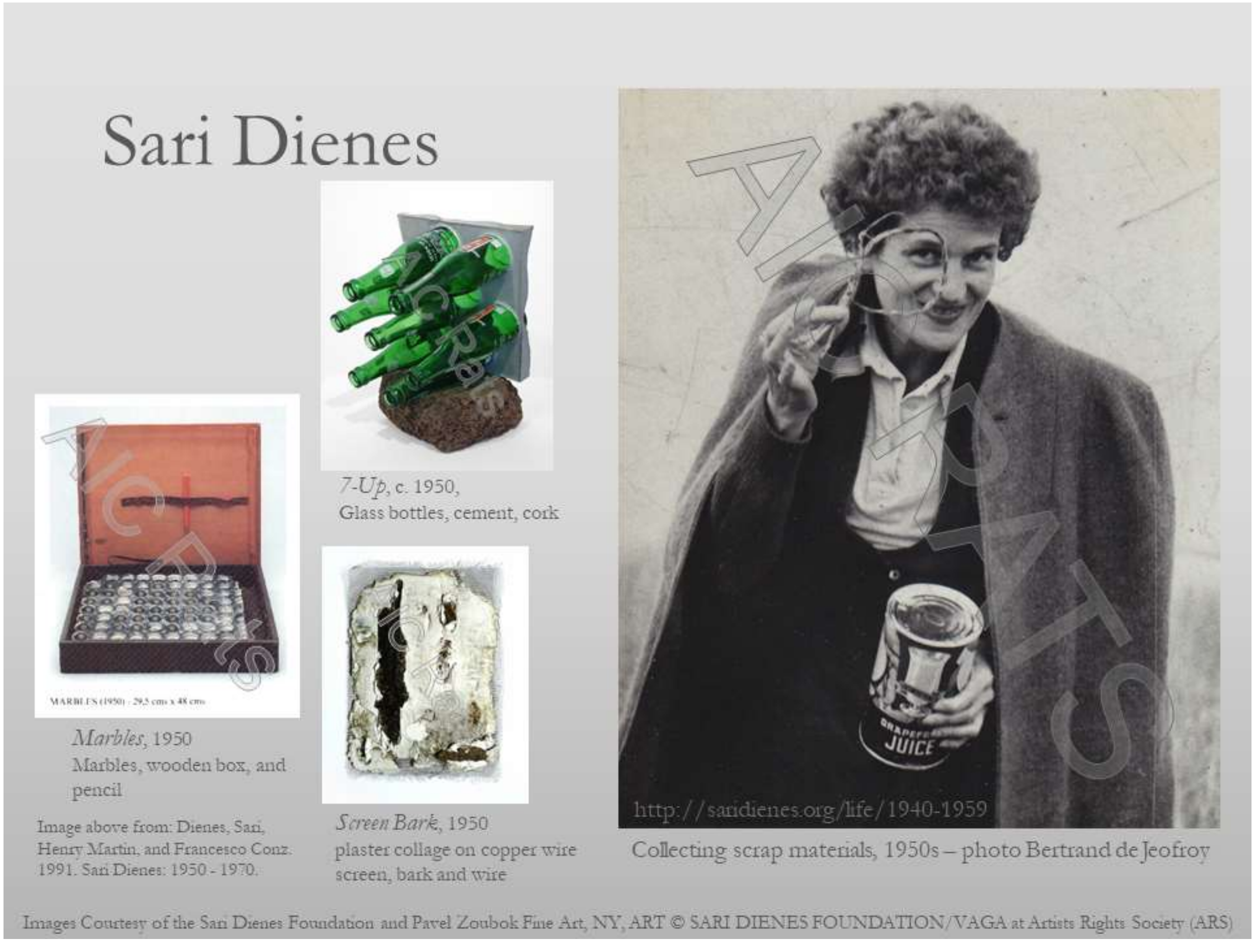
Sari's early work did receive critical recognition at the time. She had frequent solo exhibitions and was featured in People and Life magazines. Despite the general acknowledgement of her role as a pioneer in various arenas, her ceaseless experimentation has also been described as the reason she hasn't received more recognition for her role in the history of art. Dienes herself stated in 1984 "I have done too many different things to be successful and well known." And indeed a review of her work reveals a staggering range of media and techniques from ink and watercolors to oil paintings, to mixed media and assemblage.

Dienes was born in 1898 in Debreczen, Hungary as Sarolta Maria Anna Chylinska. She grew up well-to-do and multi-talented, studying first Piano and later dance. She married the Hungarian poet and mathematician Paul Dienes in 1922, moving together to Wales. It wasn't until around 1928 at the age of 30 that Sari, living in the UK, decided to seriously pursue an art career, enrolling at the Academie Moderne in Paris, taking courses several months of the year with instructors Fernand Leger, Andre L'hote, and Amadee Ozenfant. In 1939, Sari was on a brief trip to the United States when England declared war on Germany, effectively stranding her in the US.

Despite the unexpected nature of her residence in the US, Sari quickly found her footing and soon became a fixture in the New York art scene. By 1941 she was teaching art at the Parsons School of Design and at her own studio. In addition to exhibiting her work in solo exhibitions and continuing to teach at her studio and at the Brooklyn Museum Art School, she befriended other young artists including John Cage, Mark Rothko, and Ray Johnson. In 1945 she moved to a new studio on 57th street where she would continue to teach and host get-togethers.



Many of her fellow artists fondly remember these events and it was at Sari's studio that Robert Rauschenberg became re-acquainted with Jasper Johns. During one of their frequent visits, Sari gave Rauschenberg a stuffed eagle from amongst her collection of found objects, which Rauschenberg went on to incorporate into his well-known combine "Canyon."



Sari had actually been incorporating found objects in her artwork since the late 1940's. A New York Times review of her 1948 show mentions her use of "ingenious surrealist shock objects composed of driftwood and sea shell fragments."

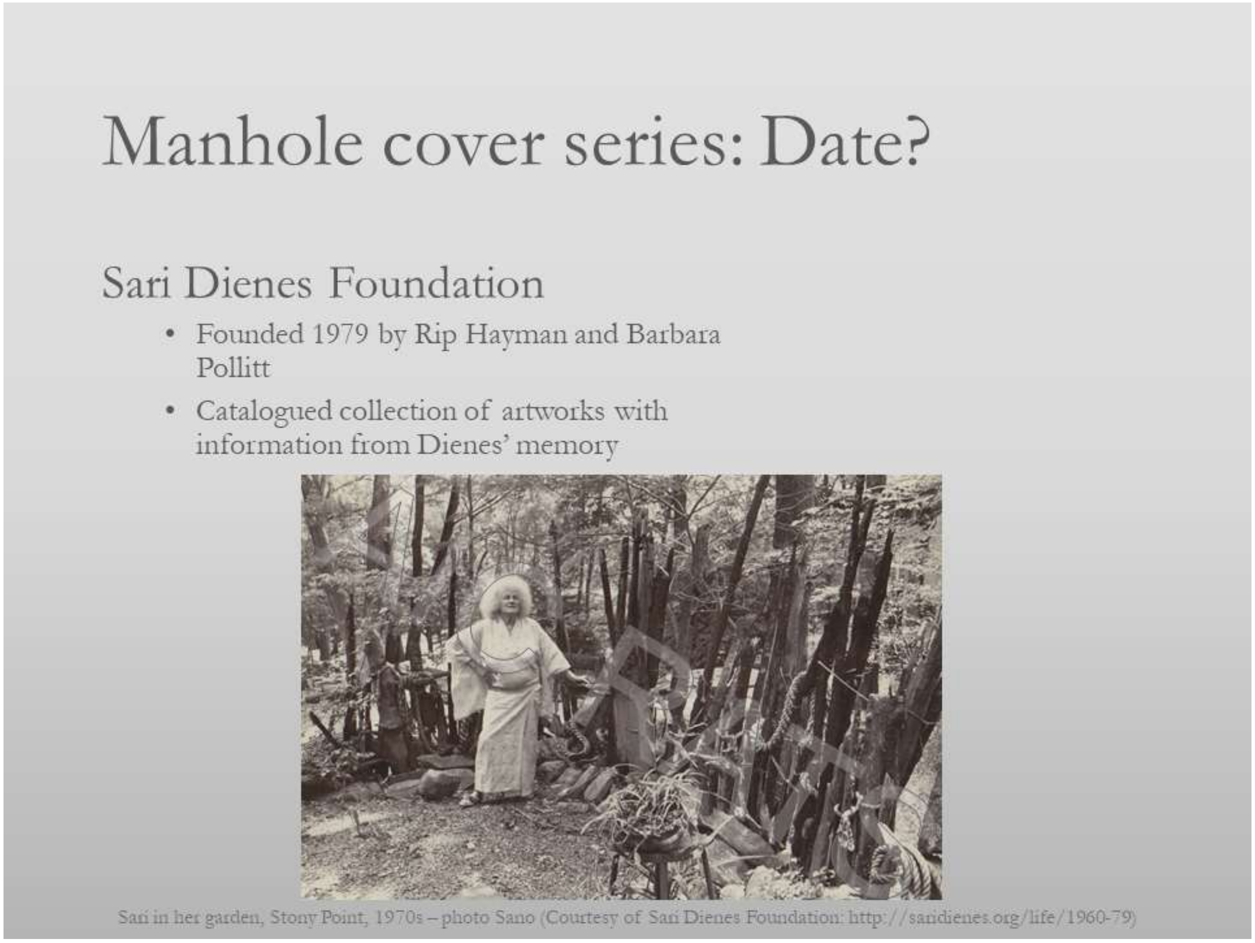
By 1956 she was incorporating all types of organic and industrial components in her artworks. The list of materials represented in one of her shows, according to a reviewer, included: "a rusty garbage-can lid… chips off a pine cone … a mannequin's leg in a whiskey bottle topped with a seashell... about one-third of a shovel… an automobile hubcap… innumerable pieces of charred driftwood….burned orange crates and scorched easels; and an enormous sheet of rusted metal…"

Sari's love of experimenting with different materials and formats continued throughout the rest of her life.

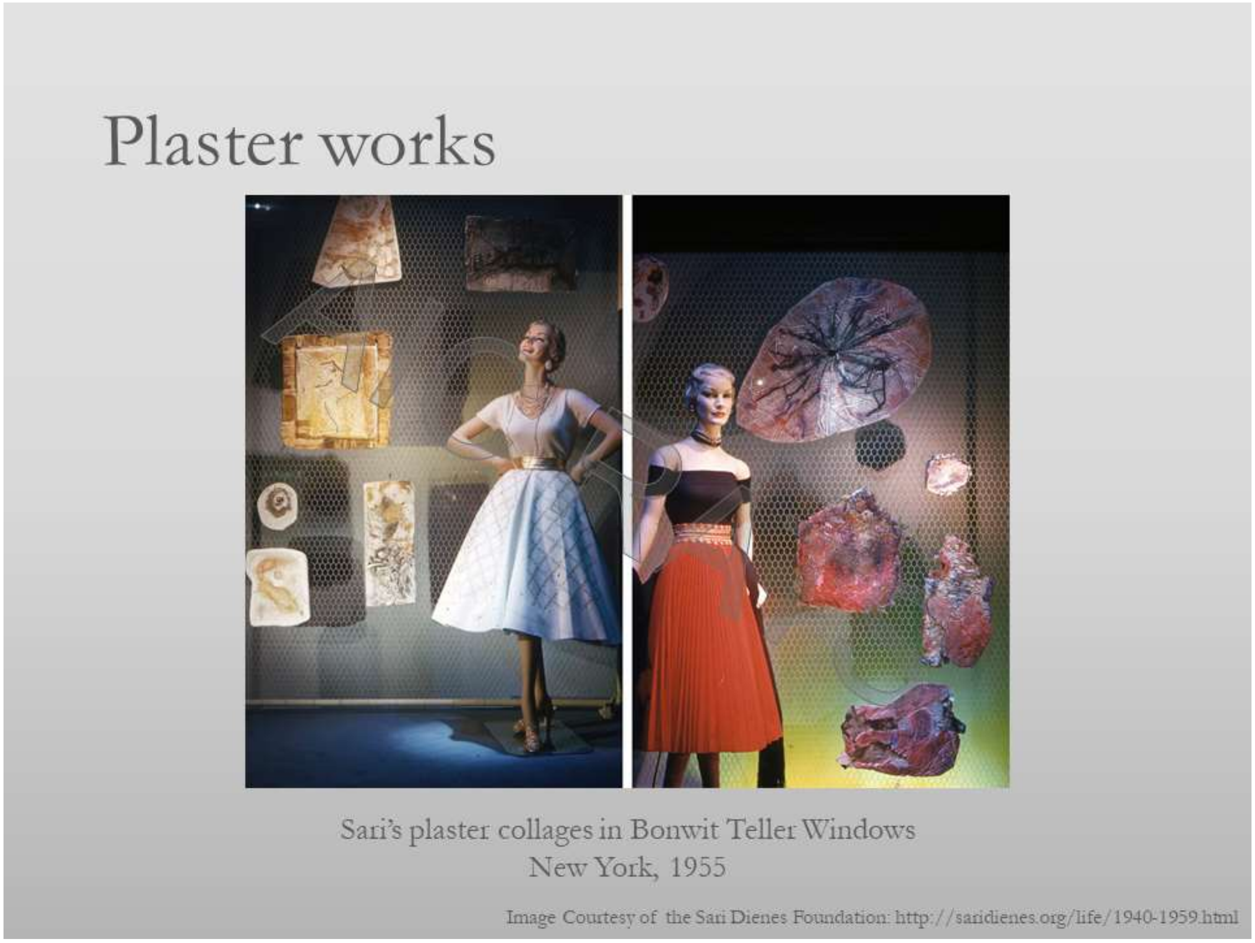
In 2016, VMFA curator, Sarah Eckhardt, acquired several of Dienes' artworks for the museum's collection, including Star Circle, pictured here on the right. In the same year, the Kunstmuseum Basel also purchased Snowflake Circle, pictured on the left, which is another in Dienes' series of 3 plaster cast manhole cover artworks, with the third, Storm Sewer, pictured here at center, purchased by a private collector.

As Dienes' sculptures had not been previously studied, her materials and techniques were almost entirely unknown. Preparation of these artworks for exhibition provided the first ever opportunity to carry out a technical study of Dienes' plaster cast pieces. Without published research to refer to, conservators at the Kunstmuseum Basel, Annette Fritsch and Werner Mueller, proposed a collaboration with the VMFA to share information gathered from the study of their two works.

While both museums were eager to install their newly acquired artworks, examination of Star Circle and Snowflake Circle after removal of their gallery frames revealed a range of condition issues affecting their stability, including a bowing and separating foam board support and flaking plaster on Snowflake circle, pictured on the top right, and a separating foam board support on Star circle, which you can see best on the right hand side of the bottom image. There was movement between the foam board and stretcher when the piece was held vertically indicating the foam board was not well-secured. The research into Dienes' materials was therefore all the more important in order to help us understand the issues affecting the stability of these works and the best potential treatment options.



One question of particular interest to VMFA curator, Sarah Eckhardt, was the dating of these works. Many of Sari Dienes' artworks only have very general dates assigned to them due to the peculiarity of how they were catalogued. Most of Dienes' artwork from her studio entered the collection of the Sari Dienes Foundation in 1979. The foundation was formed by friends of Dienes who recognized the importance of preserving her legacy. While they went through and cataloged the collection with Sari, much of the information they collected was from Sari's memory, which late into her life was not necessarily the clearest, so it wasn't always possible to obtain specific dates for many of her artworks.



The assigned date for the manhole cover series was 1950's. This date is supported by a few different pieces of information. First, Sari is known to have been experimenting with plaster casts in the early 1950's as her plaster collages, as she called them, were featured in the Bonwit Teller store windows in New York City in 1955.

http://pavelzoubok.com/artist/sari-dienes/artworks/storm-sewer-c-1950s/

Storm Sewer (1950's?), Private Collection

Images Courtesy of the Sari Dienes Foundation and Pavel Zoubok Fine Art, NY, ART © SARI DIENES FOUNDATION/VAGA at Artists Rights Society (ARS)

Secondly, one of the manhole covers she used for her series of casts is embossed with the name of a Florida Foundry, CH Lynne Foundry of Palm Beach and Sari Dienes' only documented period working in Florida was in 1954 when she held a residency at the Research Studio in Maitland, Florida.

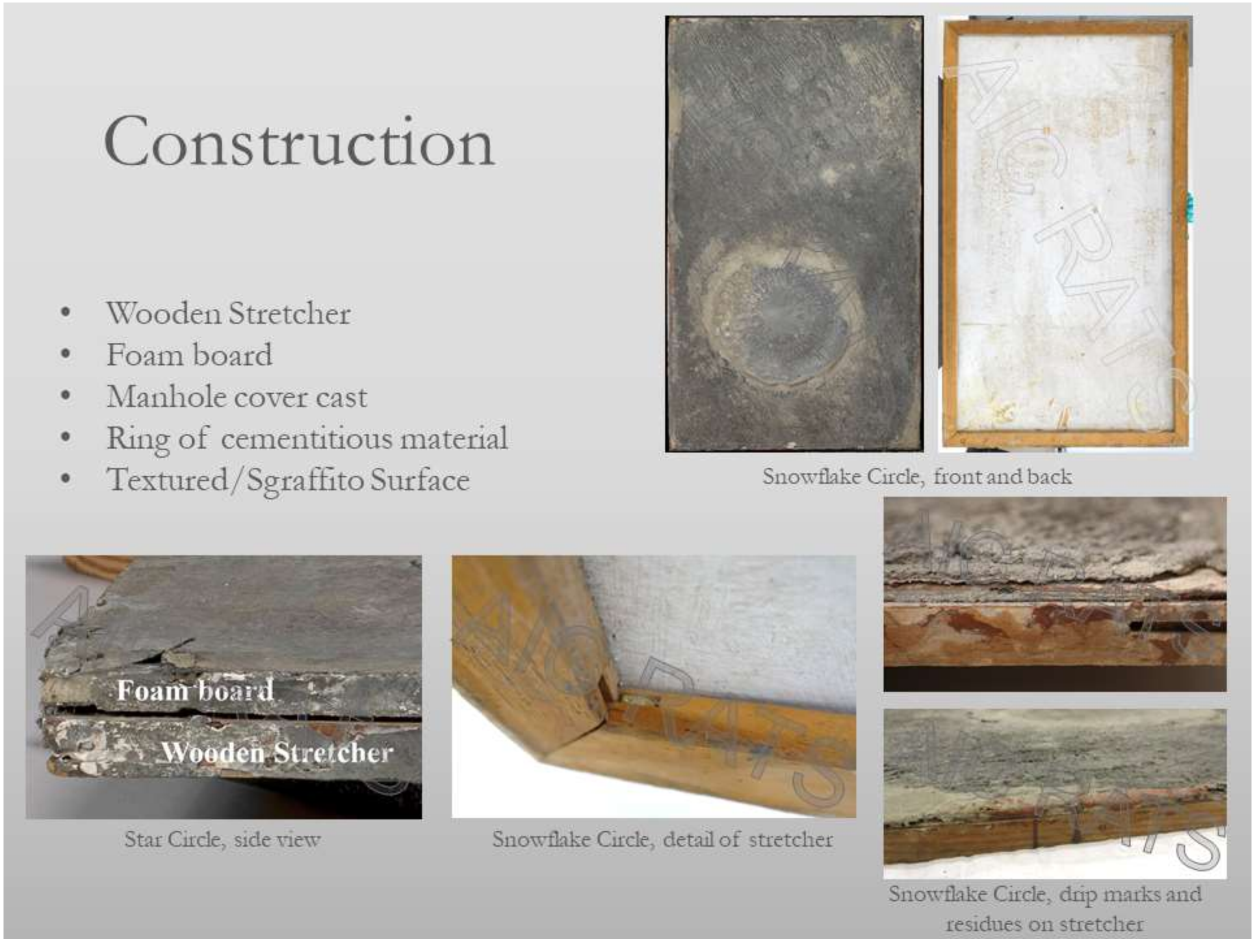
In 1953, Sari had begun experimenting with rubbings, beginning her sidewalk rubbings series on the streets of New York. She became particularly interested in manhole cover designs, which she features in many of her rubbings, including two acquired by VMFA at the same time as Star Circle, Esco and Marcy. For those that attended the AIC-RATS talks in 2017, these may be familiar as my colleague at the VMFA, Paper conservator Samantha Sheesley, presented on the analysis and treatment she carried out on these two pieces.

And In her research into the Manhole covers, Samantha actually found the manhole cover that Star Circle may have been cast from in a book on New York City Manhole covers.

So, taken together, these different lines of evidence suggest that Sari likely took the molds and possibly cast the plaster manhole covers in the early to mid 1950's. The question remained, however, as to whether the works were assembled on the foam board supports around the same time.

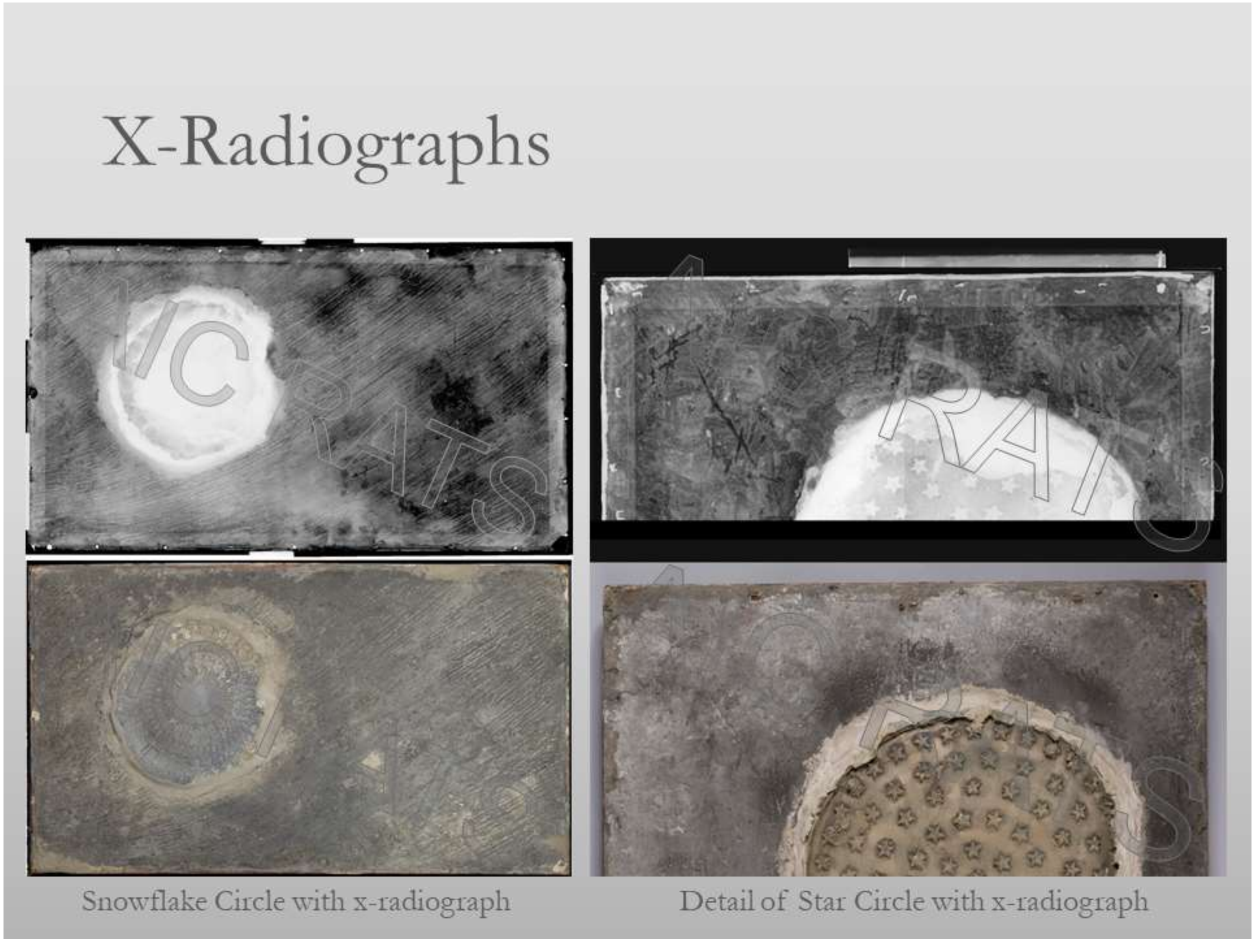
This was a particularly charged question for our curator, as the outcome could determine whether Dienes was the first artist to create this type of composition. Specifically, a rectangular hung artwork incorporating plaster casts. This is something Jasper Johns is touted as pioneering in the mid 1950's, as you can see in his 1955 work, Target with Four Faces. Johns was also pre-occupied with concentric circles, which is clearly a theme in Sari's work, such as her early 1950's manhole cover rubbings.

As Sari is known to have recycled her own artworks and materials kept in her studio, however, components may have been made at different times and assembled later. The characterization of the different materials used for Star Circle and Snowflake Circle, therefore took on an added importance as a possible means to date the artworks.



Both Star Circle and Snowflake Circle are constructed from a rectangular foam board support roughly painted white on the reverse and secured over a wooden stretcher with ferrous hardware. Secured to the fronts of the boards by a ring of cementitious material are manhole cover casts surrounded by a textured gray surface.

The stretcher is made of softwood bars with mitre joints at the corners. The width and thickness dimensions of the stretcher bars on Star Circle and Snowflake circle both match and there are a number of splash and drip marks on the stretchers from paint and other materials making up the pieces, which suggests that the stretchers are original.



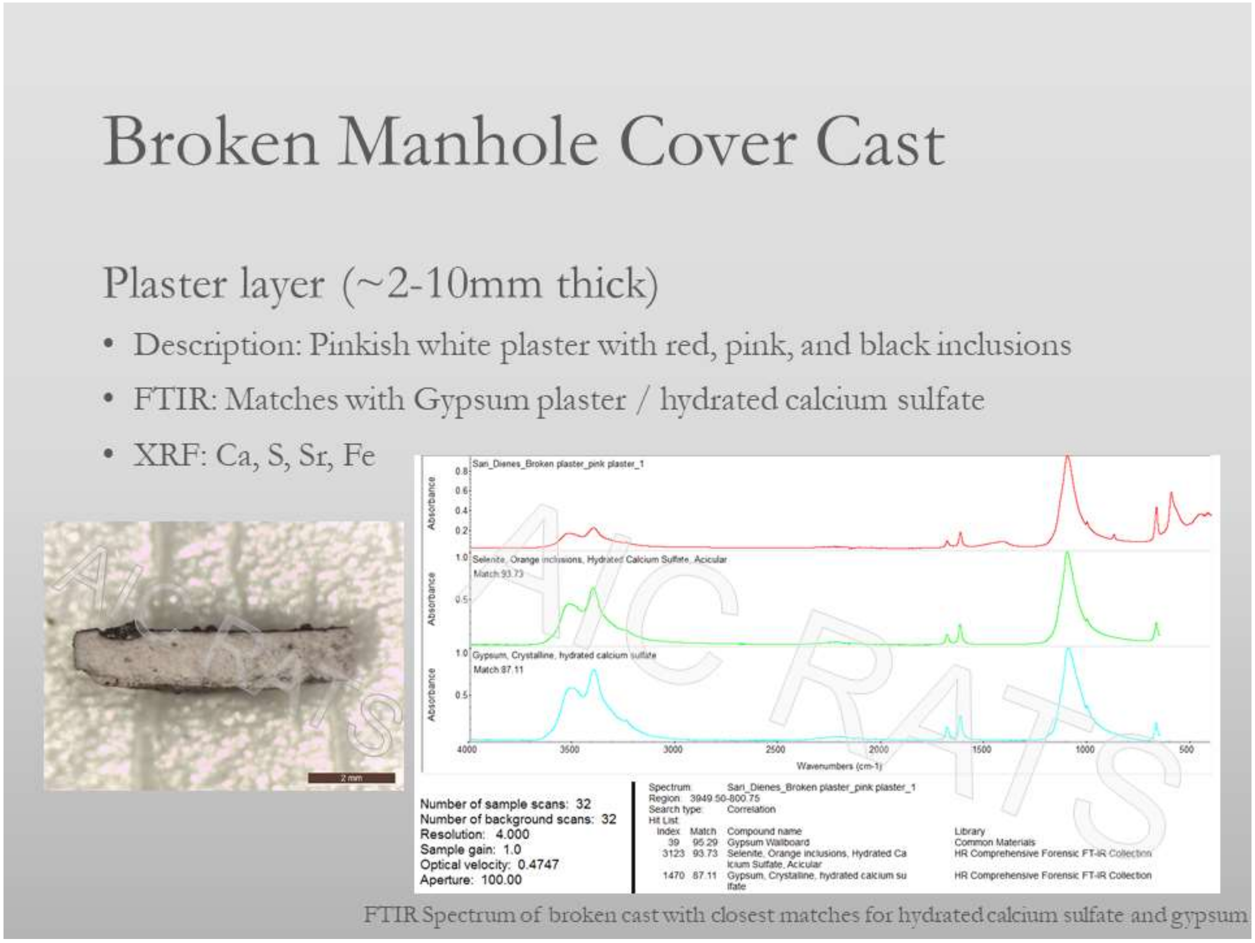
Snowflake Circle with x-radiograph

Detail of Star Circle with x-radiograph

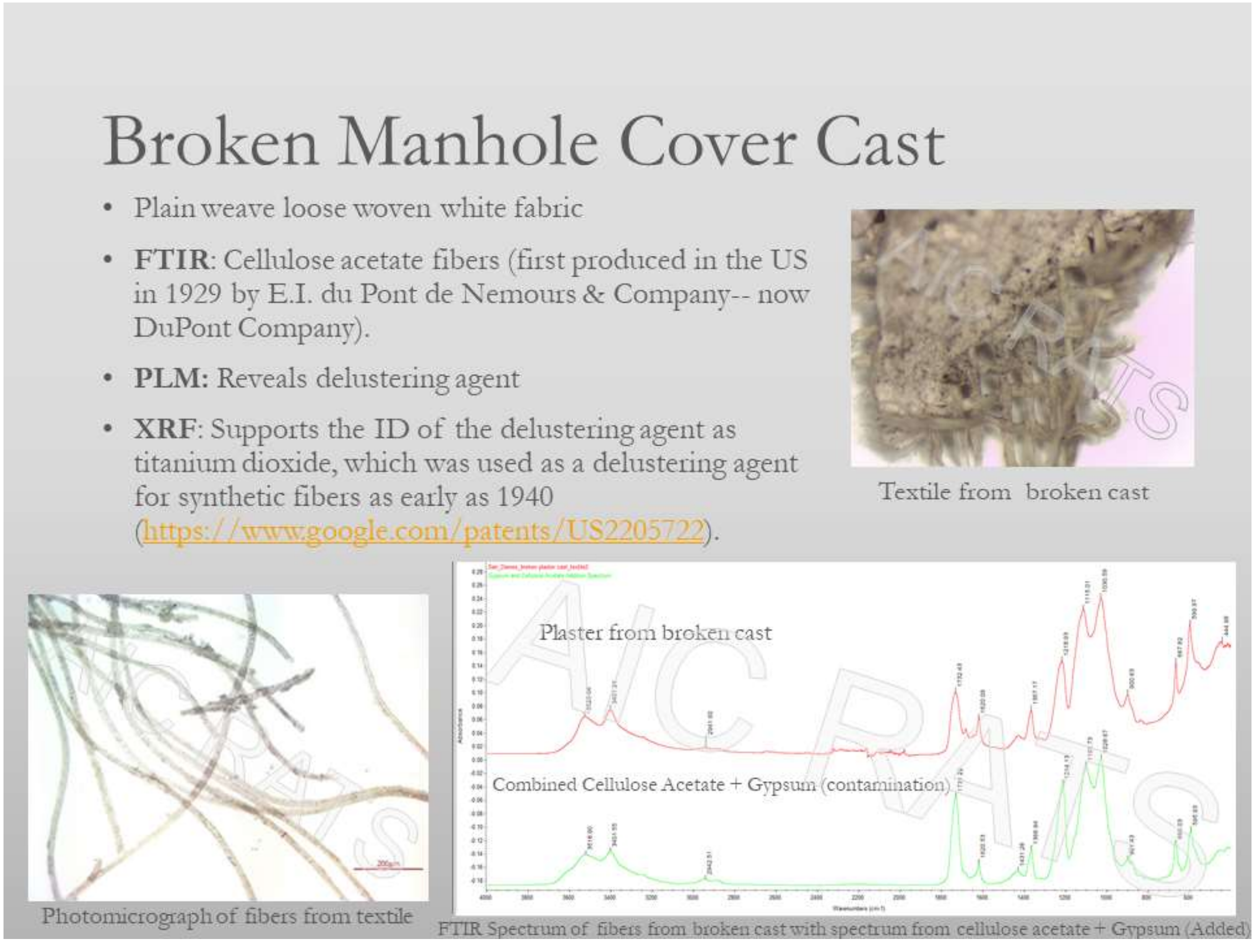
X-radiographs of both artworks show the ferrous staples and nails spaced out around the edge of the foam boards, securing them to their wooden stretchers. The x-rays also reveal that the manhole cover casts are not only anchored to the boards by the visible ring of cementitious material around the edge, but there is additional material applied underneath the casts- for Snowflake Circle, the material is concentrated at the center, whereas for Star Circle, the material is concentrated underneath the edge of the manhole cover cast.

While we were reluctant to destructively sample the plaster casts on our artworks, we were fortunate to have access to a broken manhole cover cast housed at the Sari Dienes Foundation. By examining the fragments in cross-section, we were able to better understand the structure and materials of our casts, which we believe to be comparable.

The broken plaster cast was composed of four layers. A coarse cement/aggregate mixture on the bottom, followed by a textile layer embedded in a plaster layer, which is painted on the surface with a metallic gray paint.

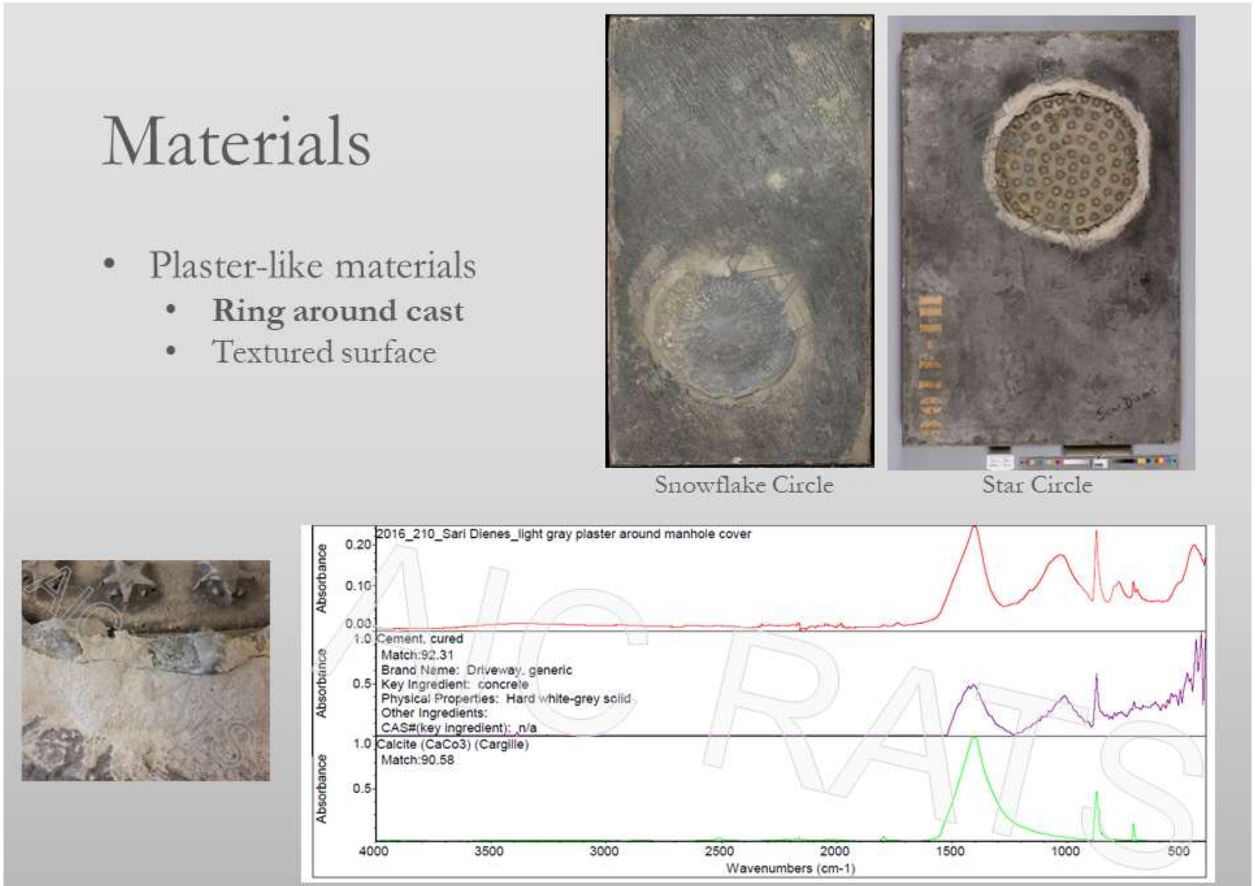


FTIR Analysis of the plaster cast indicated a gypsum plaster was used, while XRF analysis produced peaks for iron and strontium, which are typical co-occurring elements found in gypsum plasters.



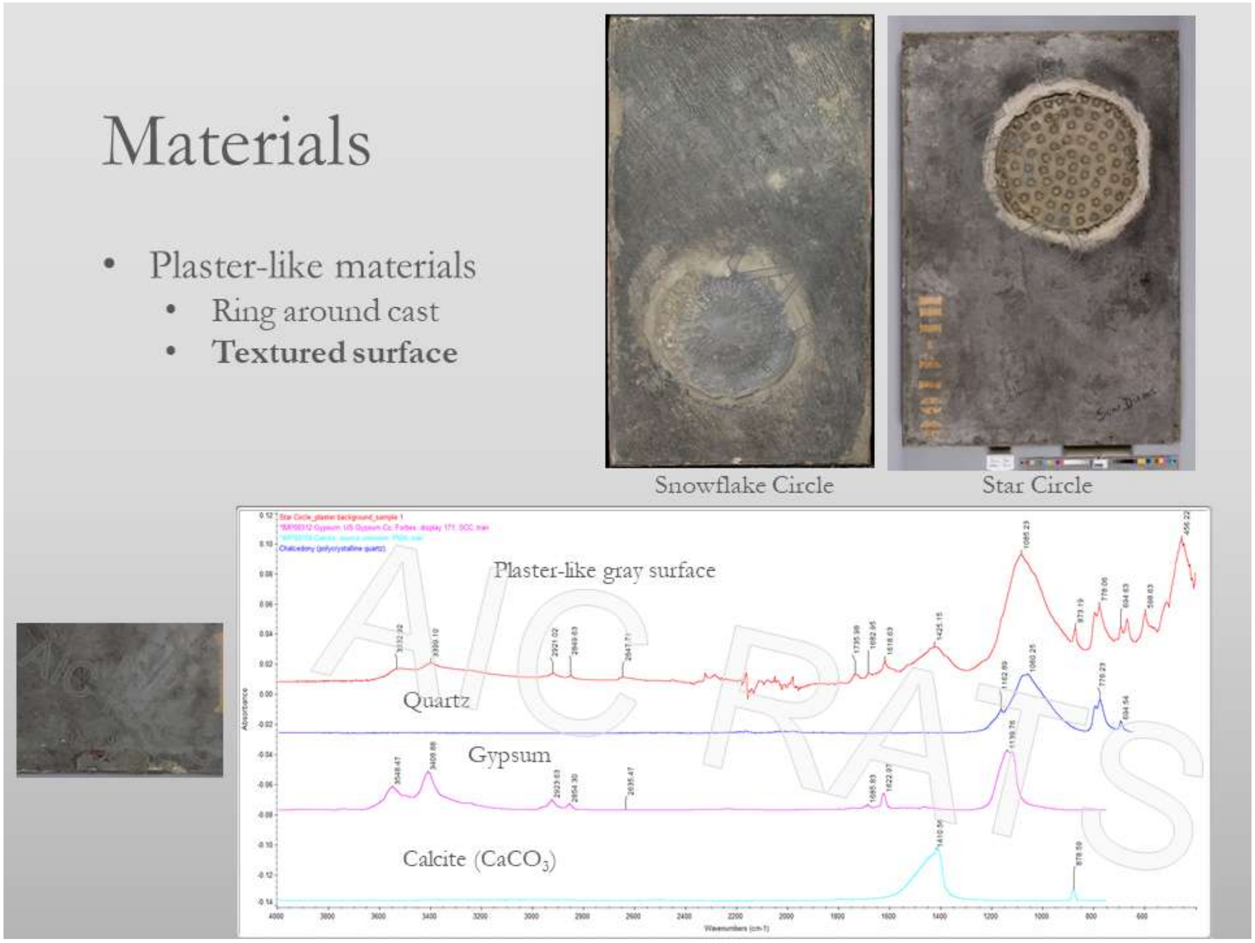
FTIR analysis of the white textile embedded in the plaster indicates that the fibers are cellulose acetate. Microscopic examination of the fibers suggests that they contain a delustering agent while analysis with XRF supports the identification of the delustering agent as titanium dioxide.

Cellulose acetate fibers have been produced in the US since 1929 and Titanium dioxide has been used with synthetic fibers as a delustering agent since 1940, so neither of these narrow down the production date.

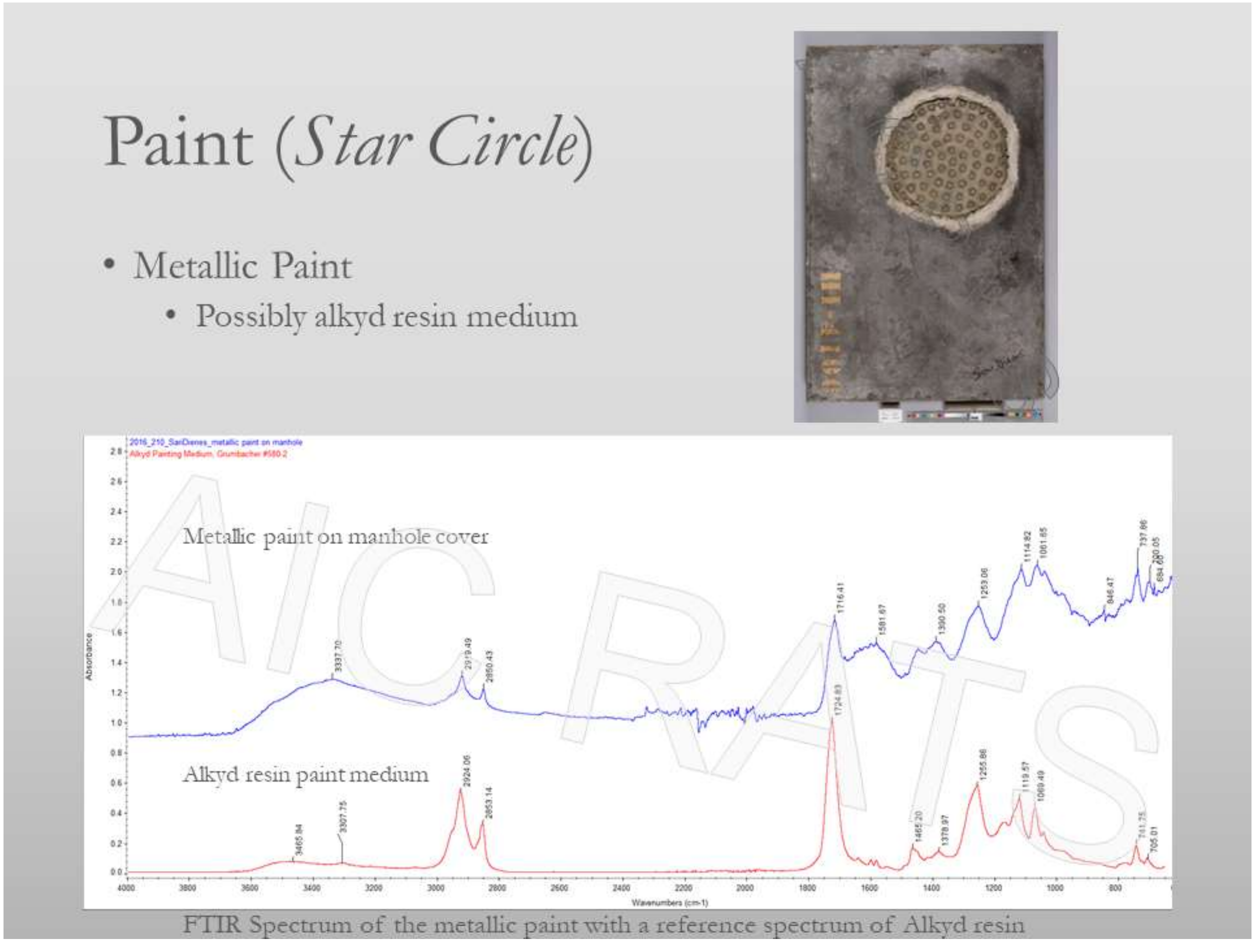


FTIR Spectrum of light gray cementitious material and highest matches for cured cement and calcite

Looking again at our two artworks, we found multiple types of plaster-like materials on their surface. We were able to confirm with FTIR that a material other than gypsum plaster was used on Star Circle to hold the plaster cast to the board, possibly a commercial mortar or cement as samples were found to contain a mixture of calcium carbonate with a silicate component. The FTIR spectrum of this material matched most closely with a reference spectrum of cured cement.

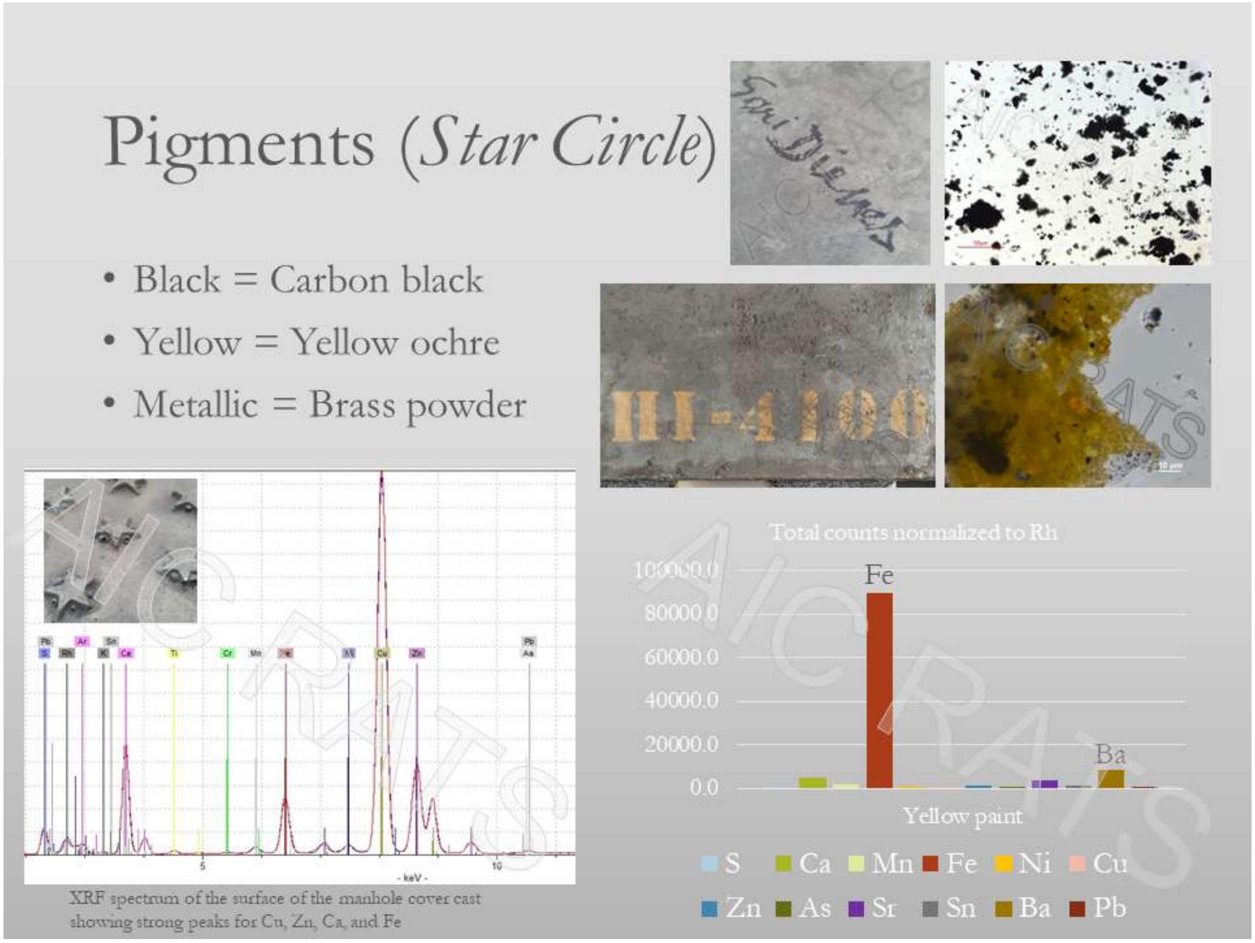


Yet another plaster-like material was used for the gray textured surface, which was found to contain a complex mixture of gypsum, limestone, quartz, and possibly additional fillers.

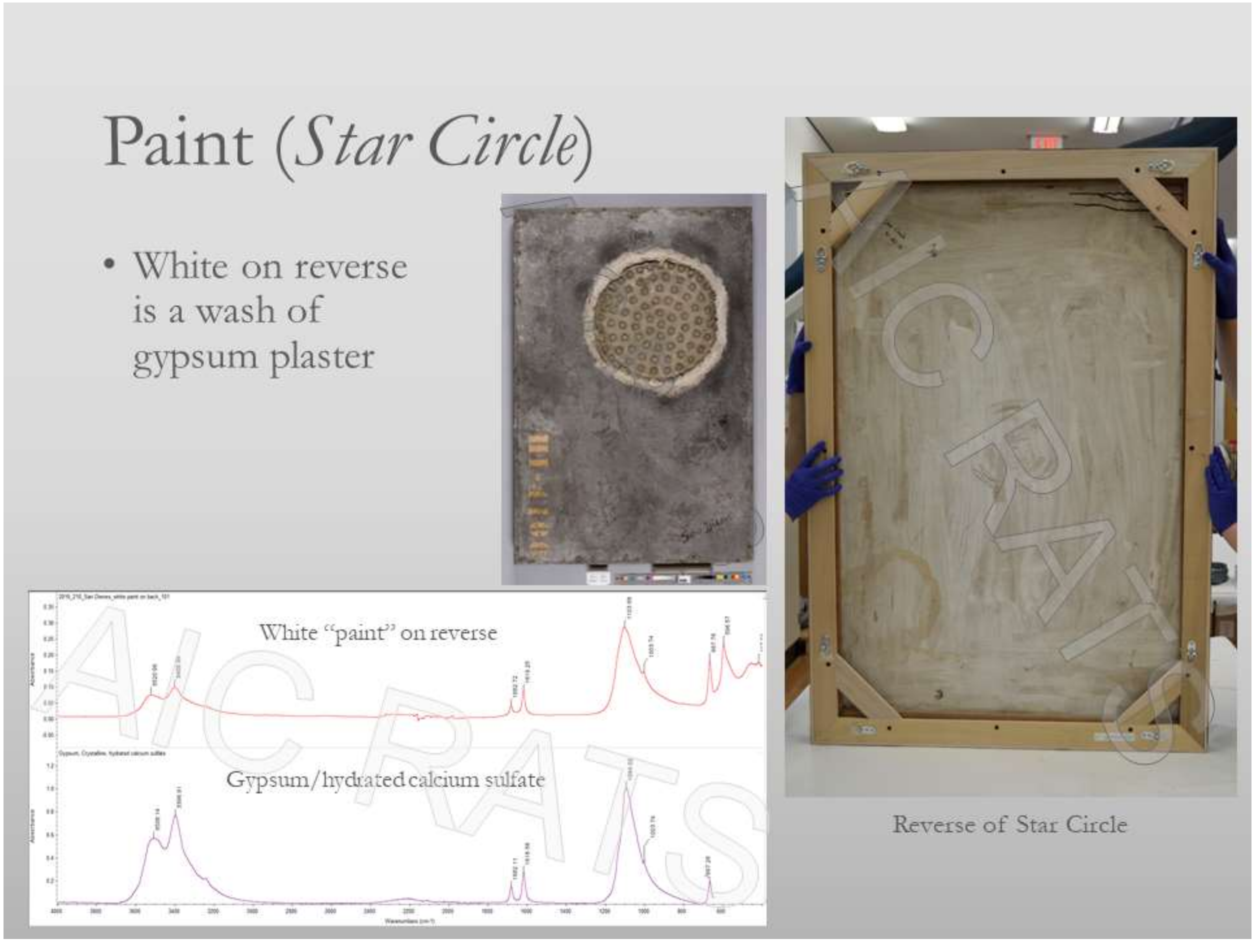


FTIR Spectrum of the metallic paint with a reference spectrum of Alkyd resin

Through FTIR analysis of the paint from Star Circle, we found evidence of Alkyd-resin medium used on the metallic manhole cover cast. While the use of Alkyd-resin paints suggests Sari may have been using commercial house paints, it doesn't narrow down a production date as Alkyds were in use since the 1920's.



XRF and PLM analysis of the pigments on Star Circle revealed that carbon black was used for the black paint while the yellow used for the stenciled lettering was a commercial yellow ochre- with barium sulfate as a filler. And the metallic surface of the manhole cover was found to contain brass powder.

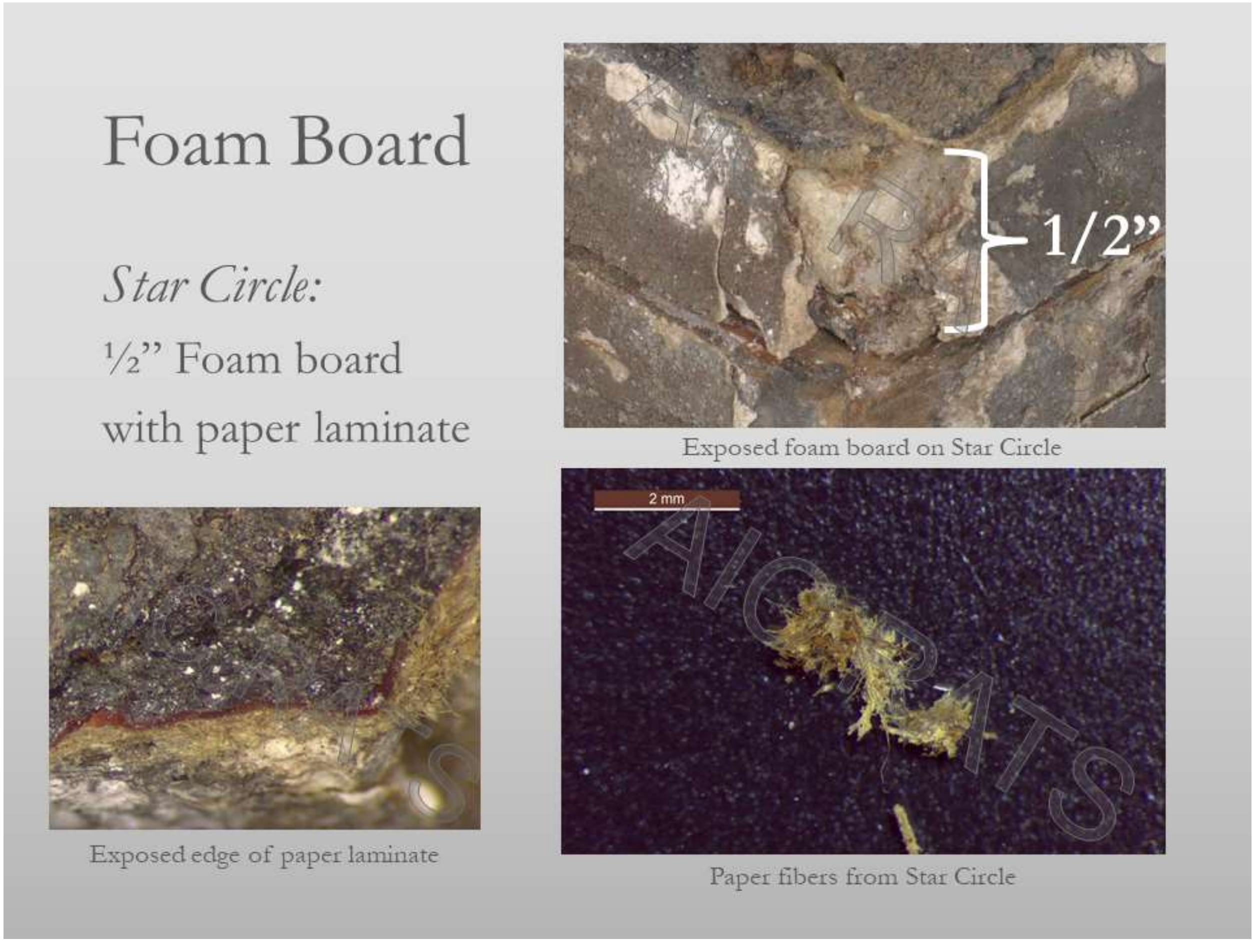


We also found that what we had thought to be white paint on the reverse was actually a wash of gypsum plaster.

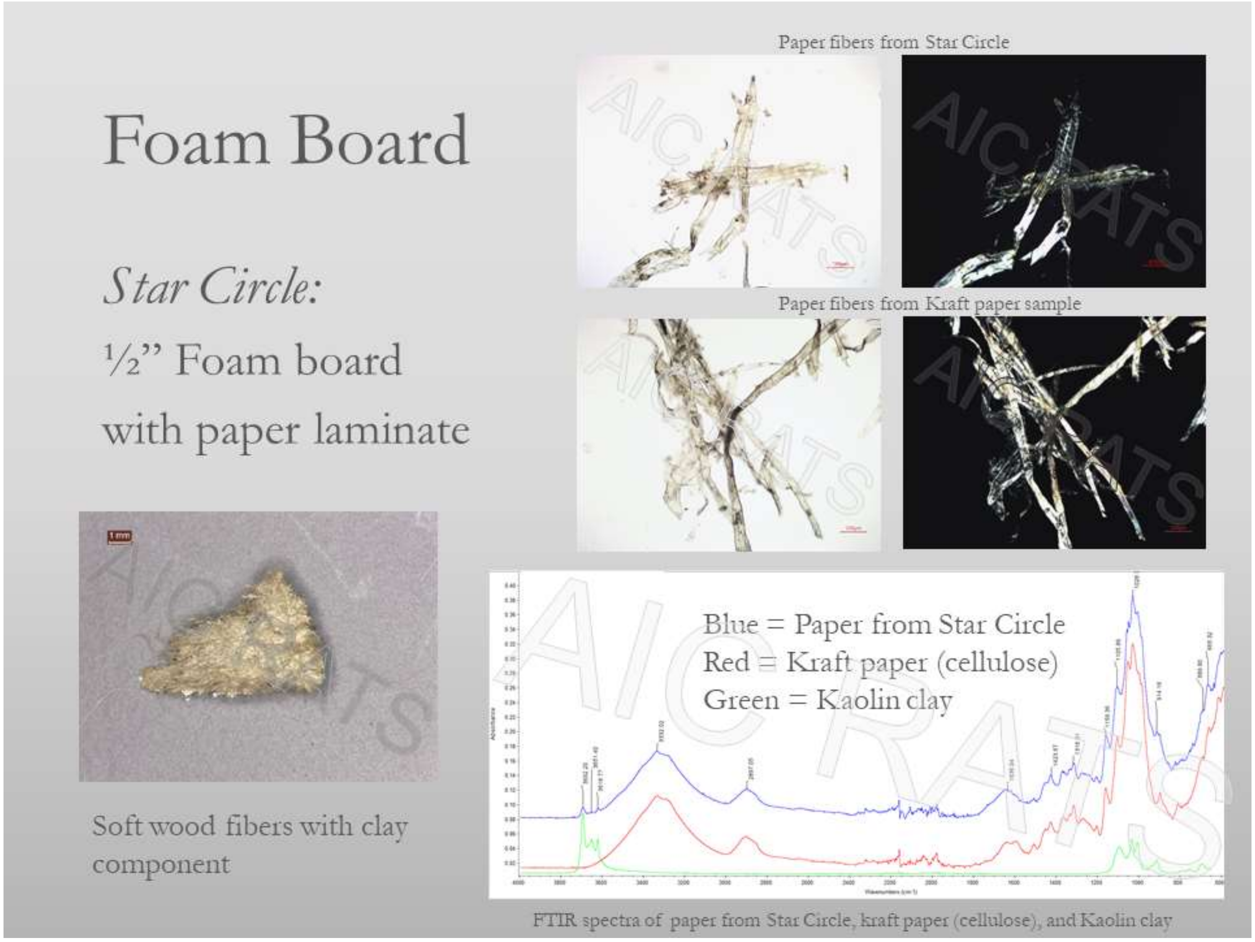
Snowflake circle, side view of foam board

Exposed foam board interior at damaged corner of Star Circle

While most of the other materials on Star Circle and Snowflake circle were commercially available for most of the 20th century, the foam board supports are another story. Foam boards only became commercially available in the US in the 1940's and went through various permutations and manufacturing changes from the 40's through the 1960's. We therefore hoped that by researching the history of foam boards, we would be able to identify key features to compare with our boards, thus narrowing down the date range within which Sari could have assembled the plaster cast to the supports.

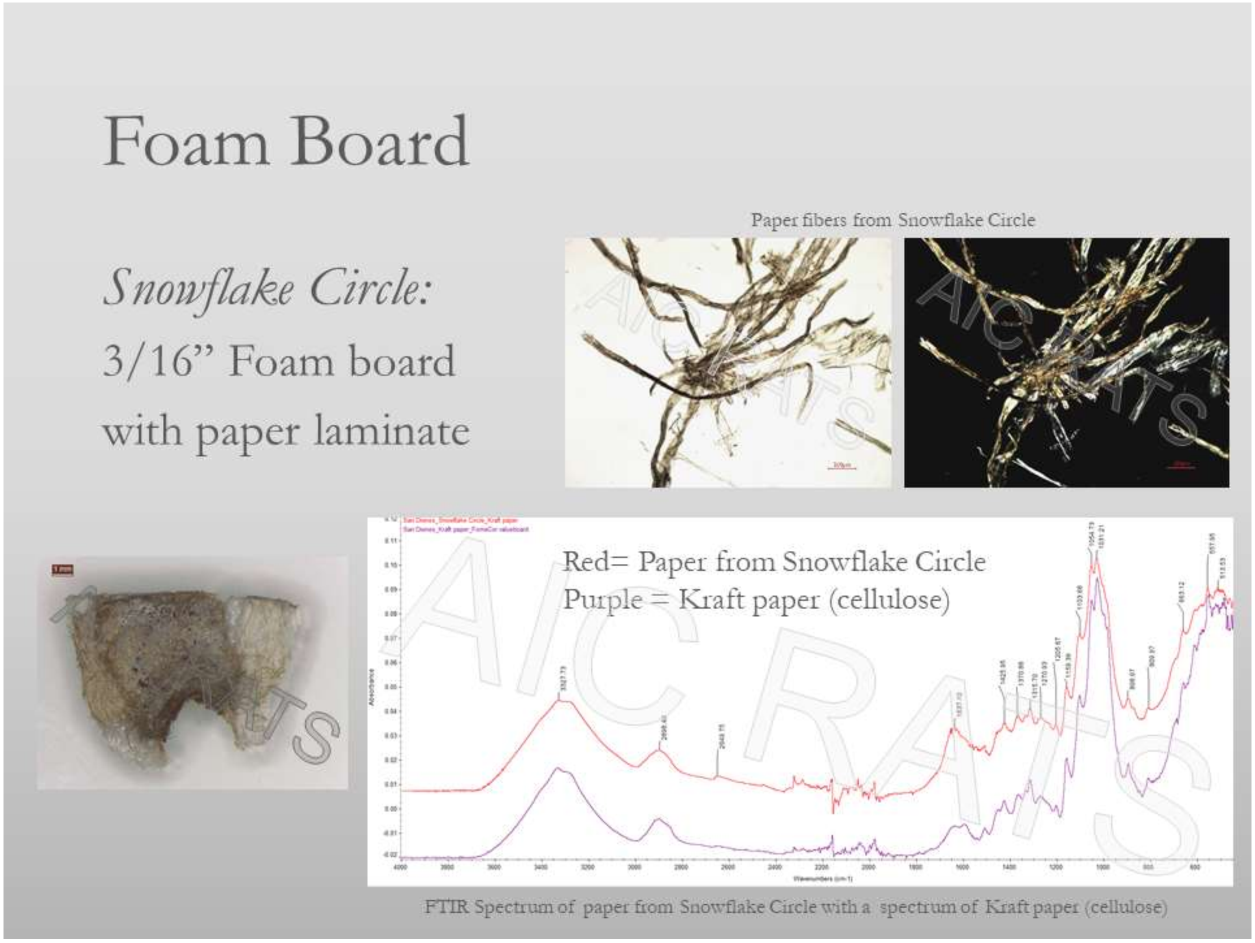


The foam board used as the support for Star Circle is ½" thick, measures 32" x 48", and is laminated on both sides with a thick yellowed paper. The paper facing on both sides is likely a heavy kraft paper. It appears heavily degraded and was found to delaminate easily.

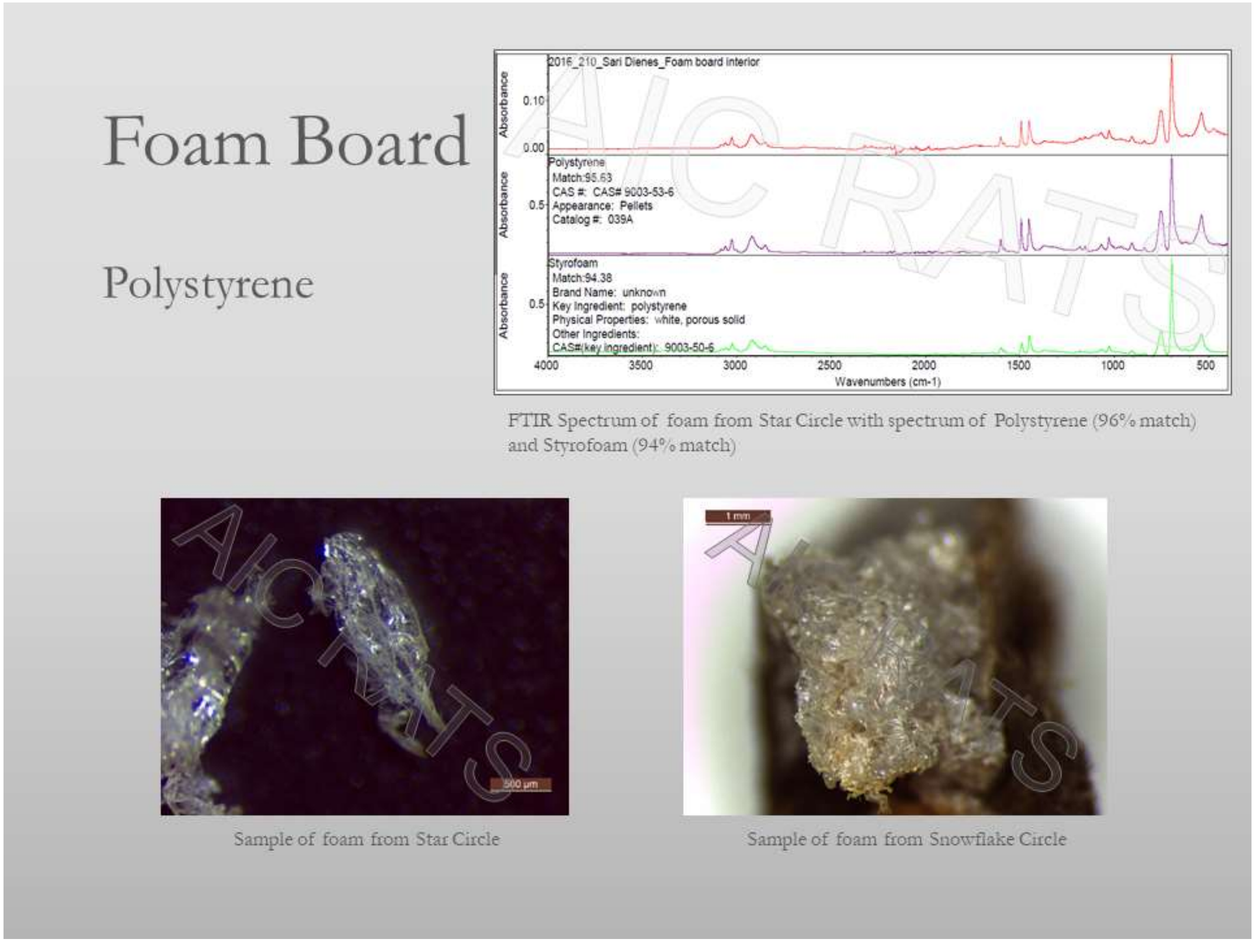


Examination of the fibers under the microscope revealed soft wood fibers and analysis of the paper facing with FTIR produced a match for cellulose with a minor component of clay, possibly a filler or else contaminant from the surface. There was no additional resin detected, as might be present with a resin-impregnated veneer.

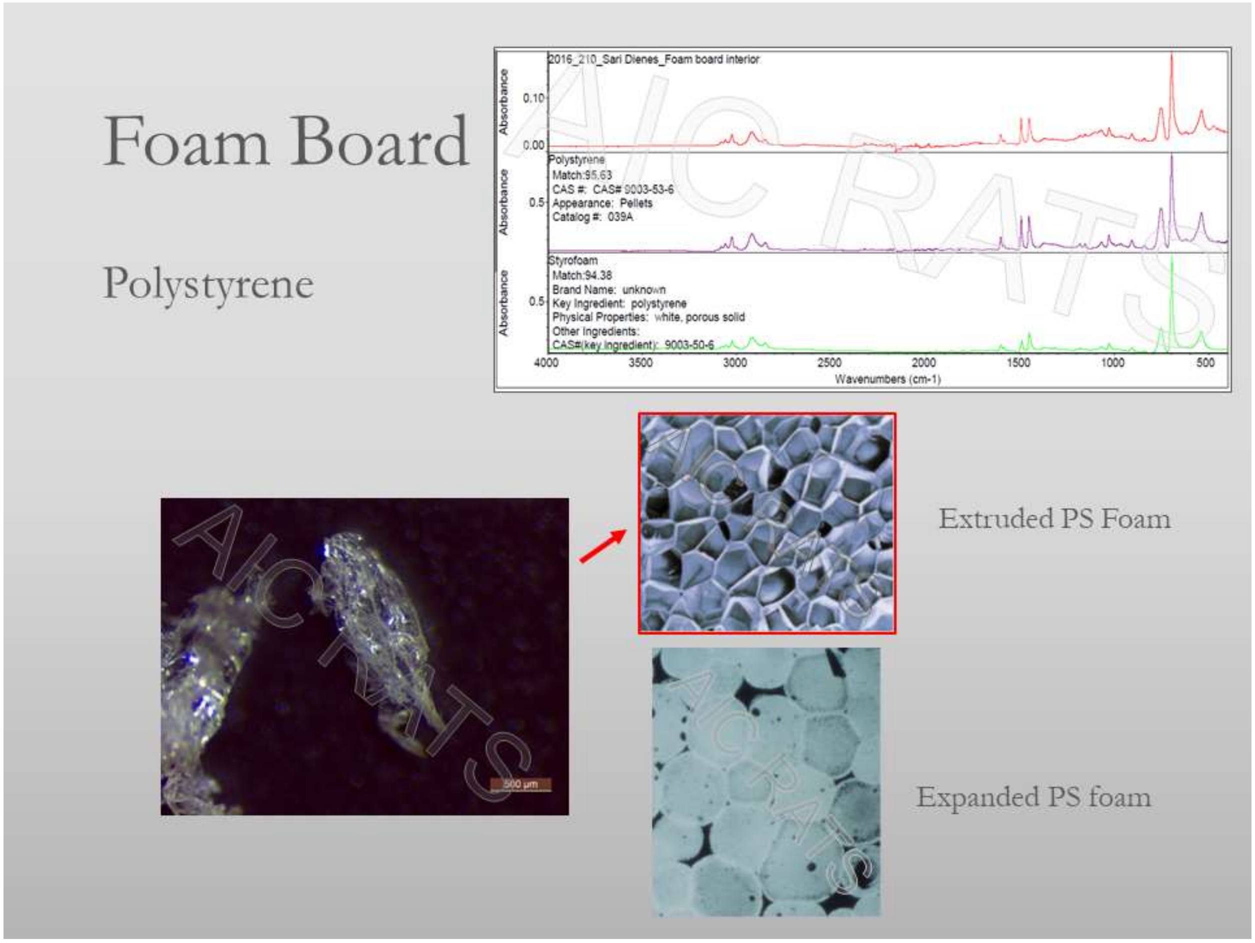
The foam board used as the support for Snowflake circle is only 3/16" thick, measures ~27.75" x 47.5", and is also laminated on both sides with a thick yellowed paper, similar to that found on Star Circle. The board appears to be cut by hand as it is not square and has uneven edges.



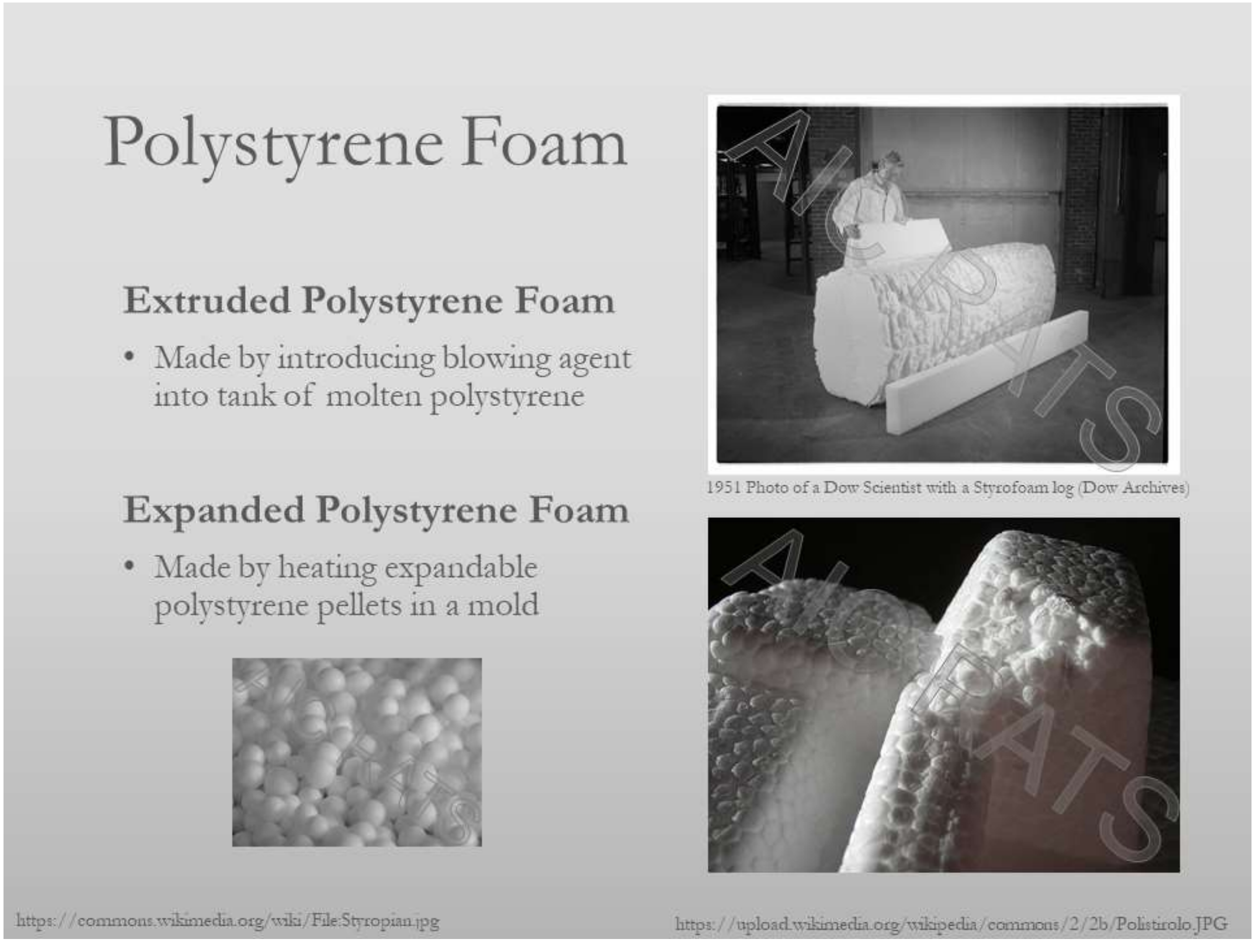
Examination of the fibers under the microscope also revealed soft wood fibers while FTIR analysis produced a spectrum consistent with just cellulose and no fillers.



We were able to identify both foam boards as polystyrene foam using FTIR.



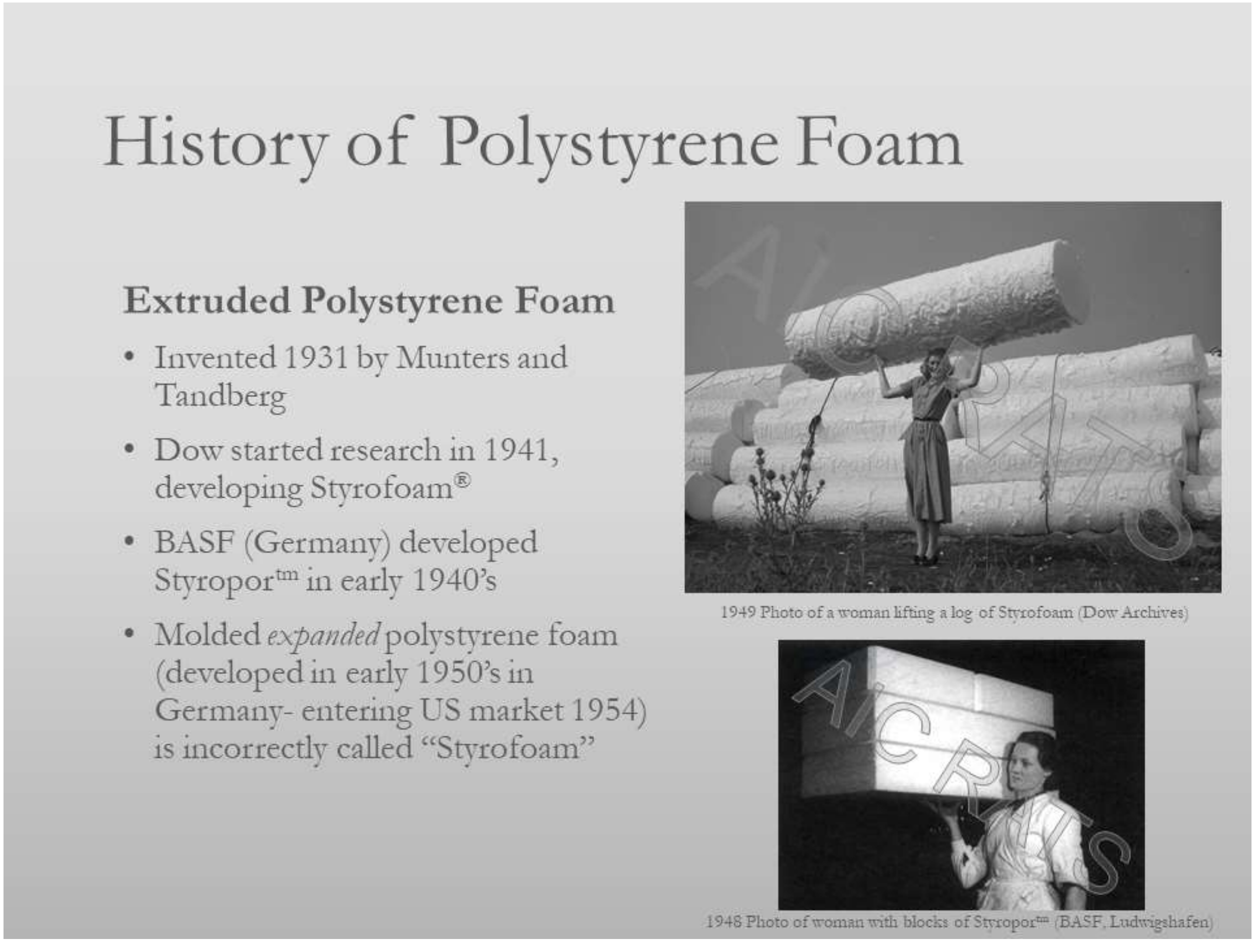
Examination of the foam under magnification revealed a hollow closed-cell structure indicating the foam is extruded polystyrene.



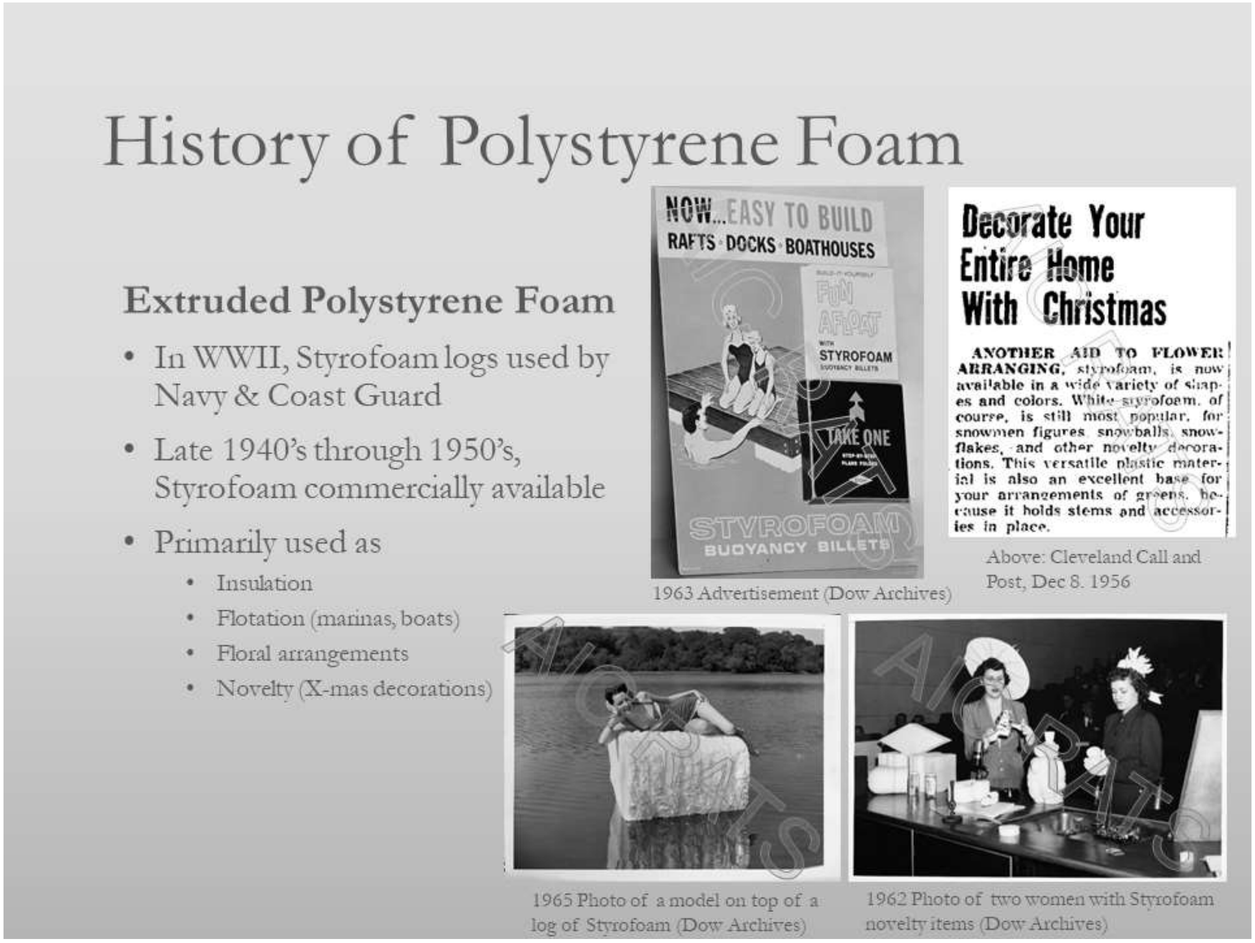
Extruded polystyrene foam, as opposed to expanded polystyrene foam, is made by introducing a blowing agent (solvent with low boiling point) into a tank of the molten polystyrene at elevated temperature and pressure. Upon extrusion of the mixture from an outlet in the tank, the blowing agent expands and the foam cools, solidifying in its expanded form.

The early Dow Tower process of extrusion produced large foam logs that can then be cut into planks- (as in the top right photo).

Expanded polystyrene is instead produced from expandable polystyrene pellets. The pellets are introduced into a mold and heated. The beads expand, fuse together, and take on the shape of the mold. While products made of expanded polystyrene foam, such as cups, are often referred to as Styrofoam, it's actually only the extruded foam that is technically Styrofoam.

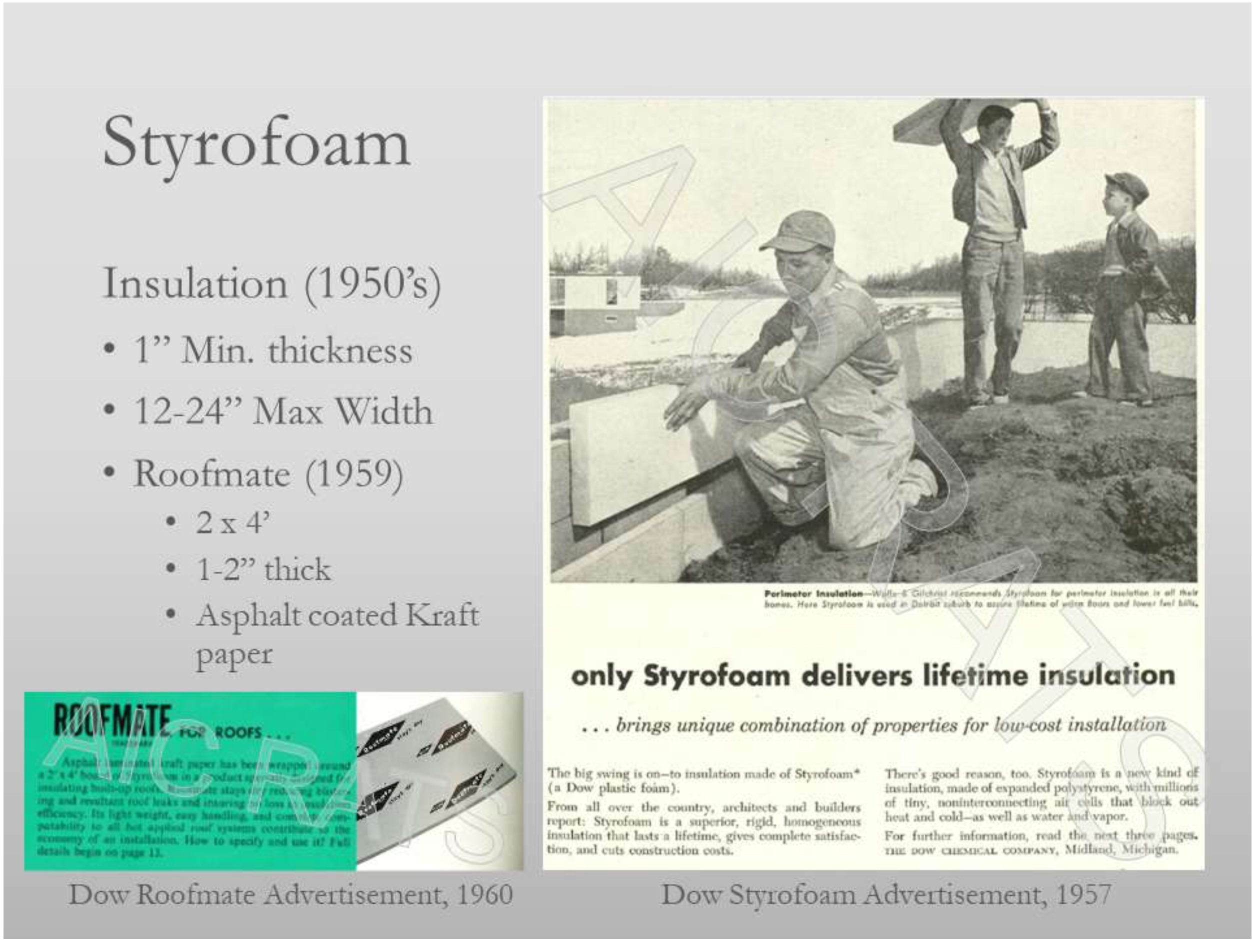


While cellular polystyrene was first patented in 1931 by Swedish inventors, Dow Chemical Company started research in 1941 to develop a commercial process for production of polystyrene foam, which they trademarked Styrofoam. BASF, In Germany, developed its own process for foaming polystyrene in the early 1940's, naming the product Styropor.

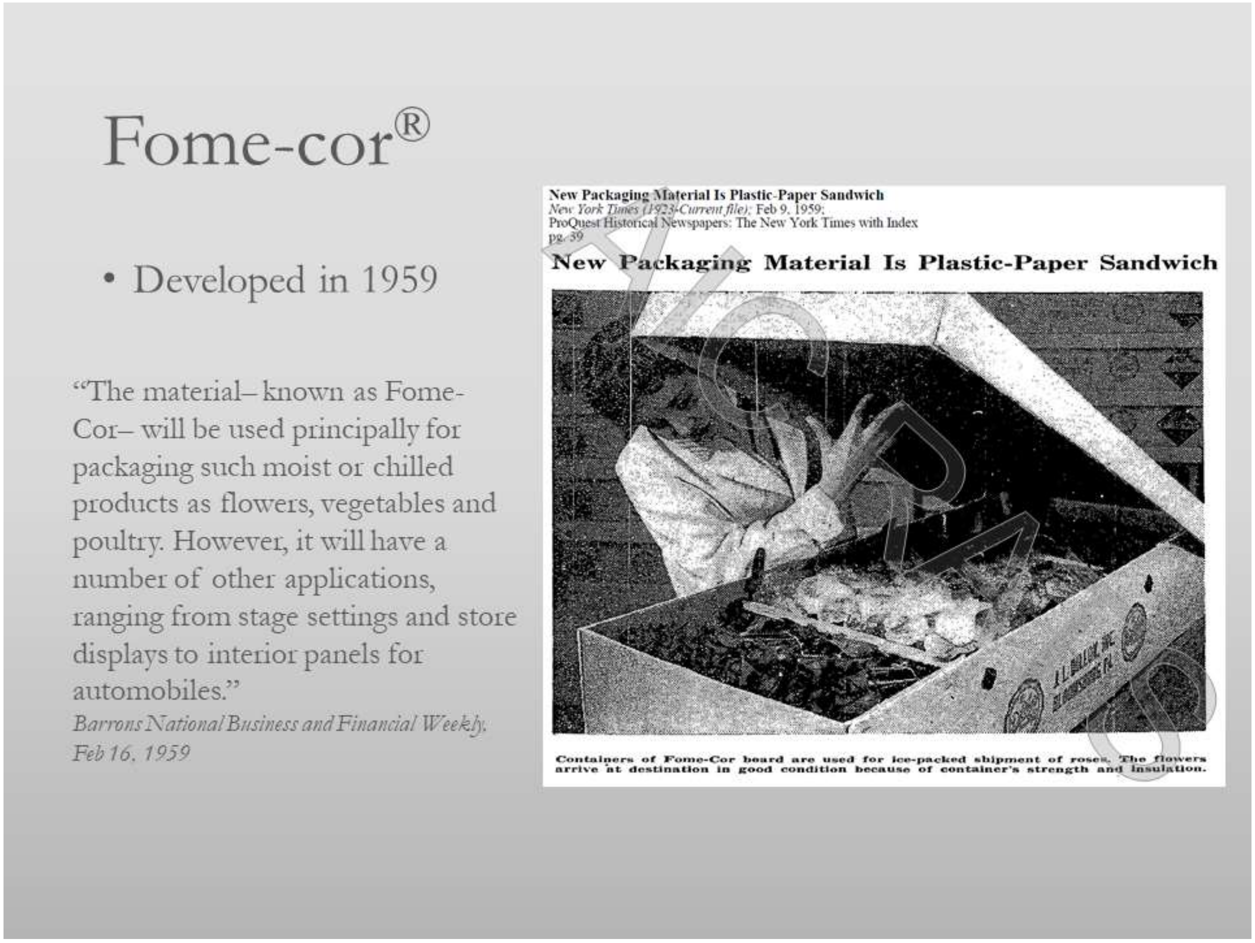


During the war, Styrofoam logs were used as flotation devices by the US military but after the end of the war, Styrofoam began to be used for a variety of applications. By the late 1940's through 1950's, Styrofoam was commercially available.

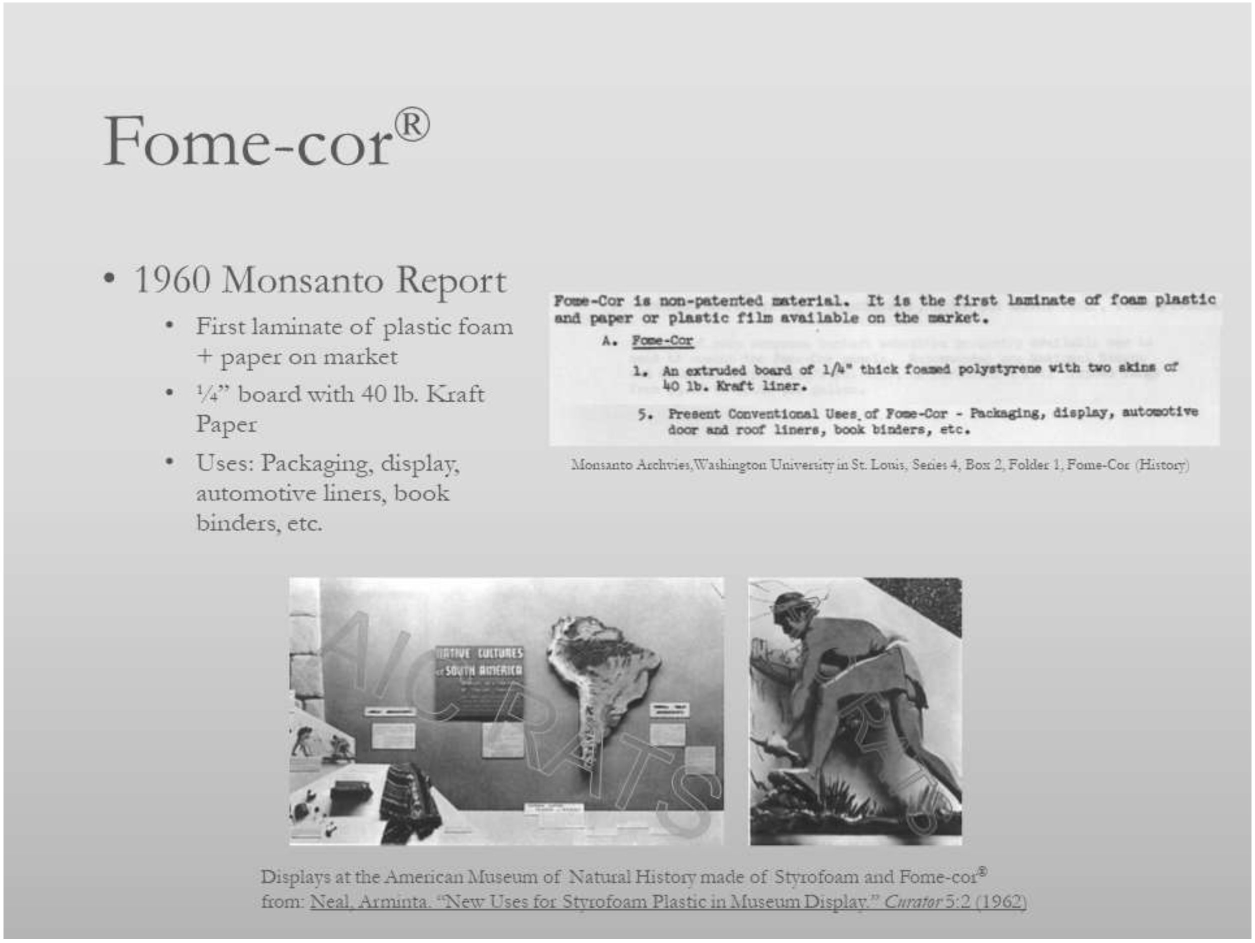
Since we were hoping to find evidence that the foam board supports were from the early 50's, I scoured the archival sources for information on the production and use of Styrofoam from that time period and I found that Styrofoam was primarily used as insulation boards in the construction industry, but also for flotation and boating, as well as for novelty and craft items, such as floral arrangements and Christmas decorations.



I was unable to find evidence for the use of Styrofoam boards in the 1950's as artist supports but considered the possibility that Sari could have re-purposed insulation boards, adding a paper layer. Unfortunately, the sizes of boards produced by Dow in the 1950's do not match the dimensions of the boards used in our artworks. The minimum thickness sold by Dow through the 1950's was 1" thick while the maximum widths were between 12" to 24. And none of these Styrofoam planks came laminated with paper. While paper could have been adhered to the surface later, I did not find any adhesive residue on any samples taken from the interface between the paper and foam. The paper therefore appears to have been heat bonded to the foam interior by the manufacturer. In 1959, Dow did begin selling a Styrofoam board laminated with Asphalt coated craft paper, called Roofmate. But again, these boards were only sold in 2 x 4 foot pieces so couldn't have been used for our artworks.



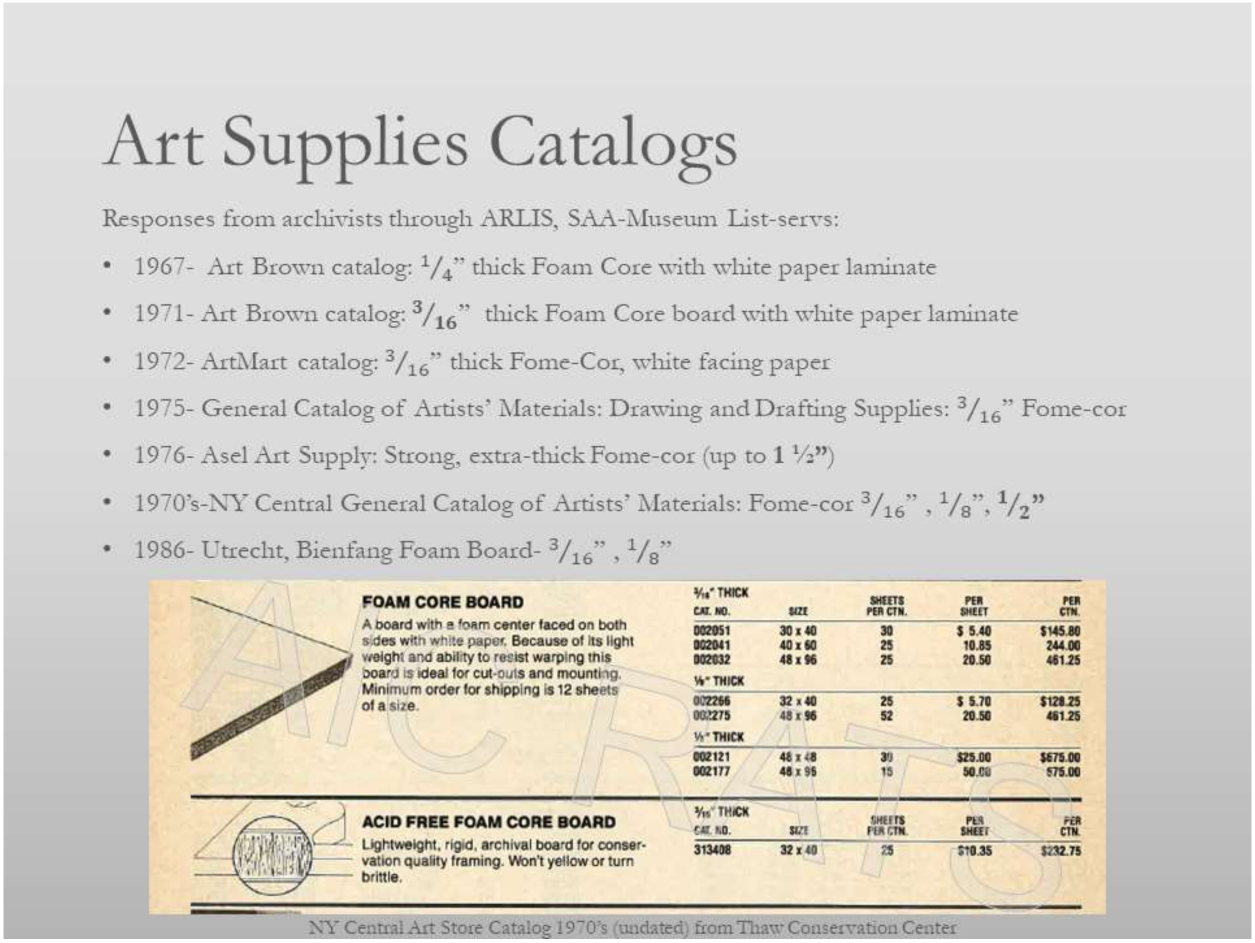
In 1959, Monsanto entered the foamed polystyrene game, partnering with St. Regis Paper company to produce Fome-cor, an extruded polystyrene foam board laminated with paper on either side. Fome-cor was originally developed for packaging, but was also marketed for other applications such as graphic displays, and panels for automobiles and light-weight construction projects.



In a 1960 internal Monsanto report on Fome-cor, the author writes: "Fome-Cor is a non-patented material. It is the first laminate of foam plastic and paper … available on the market"

The Material specifications listed in the same report are: "1/4" thick foamed polystyrene with two skins of 40lb Kraft liner"

Unfortunately there were no other documents in the Monsanto archives on the early production of Fome-Cor, so I had to look elsewhere to find the dimensions that were being produced early on. One of the earliest references was a 1962 Article on the use of plastic foams for making museum displays. This article mentions Fome-cor, with the author writing that it "only comes in 1/8" or ¼" thick"… covered on each side with a smoothly bonded layer of heavy Kraft paper.



Since ½" and 3/16" thicknesses of Fome-cor are not mentioned in these early references, I hoped that the available dimensions could be found in art supply catalogs from the late 1950's through the 1960's. But in my attempt to find this information, I discovered there is no formal archive of mid-century art supply catalogs. Working with VMFA's archivist, we put out a call to several archives listservs and from the response, were able to cobble together a handful of catalogs, listed here. While a 1971 catalog references 3/16" Fome-cor, an un-dated mid-1970's catalog includes both ½" and 3/16".

So at least by the 1970's a variety of thicknesses of Fome-cor were available, but without more detailed information in the Monsanto archives or a more comprehensive collection of art supply catalogs, I can't say with certainty what year the different thicknesses first came on the market. And by the 1980's, a range of competing foam board products had become available, including Gatorfoam, Bienfang, Foam-X, and Amoco foam boards.

In addition to looking for archival resources on foam boards, I also searched for mid-century artworks mounted on foam boards using a variety of databases. My search produced only a handful of artworks with Fome-cor or foam board listed under materials. The earliest example was a 1968 collage titled 'Democratic Ticket' in the National Portrait Gallery that measured ¼" thick. There were also a number of architectural models made with Fome-cor, but these dated to the 1970's. So unfortunately, this line of questioning didn't produce any new clues for the dating of our pieces.

Compositional analysis of the foam boards could potentially provide another way of narrowing down a date. It's possible that changes in additives and blowing agents could be detected and measured in known reference samples using more sensitive analytical techniques. While this was beyond the scope of our research, it could be an interesting project for somebody with access to the right equipment.

So our ultimate conclusion regarding the creation date of these two pieces is that the plaster casts likely were made in the mid- 1950's, however, they could have only been assembled to the foam boards post 1959- possibly in the 1960's. This was a bit of a disappointment as it would have been a satisfyingly simple narrative for Sari to have been the innovator behind this specific type of composition. Yet, the true history appears to be more complex and unfortunately more mysterious. We still don't know, for example, what the stenciled letters mean on Star Circle. Perhaps it's a reference to Johns' work incorporating stenciled lettering- or perhaps a hidden message.

But despite our conclusion that these works post-date similar artworks by Johns (and others), this in no way diminishes the contributions and importance of Dienes as an innovator and artist. Asked outright to name his most significant influence, Jasper Johns is quoted in the Art Journal saying "It was Sari Dienes."

The treatment of Star Circle was carried out at the VMFA to prepare it for installation in the permanent galleries. The heaviness of the plaster cast and potential for damage to the aged polystyrene foam board led us to minimize any handling of the relatively brittle foam board and to keep the artwork flat on its back for the entirety of the treatment.

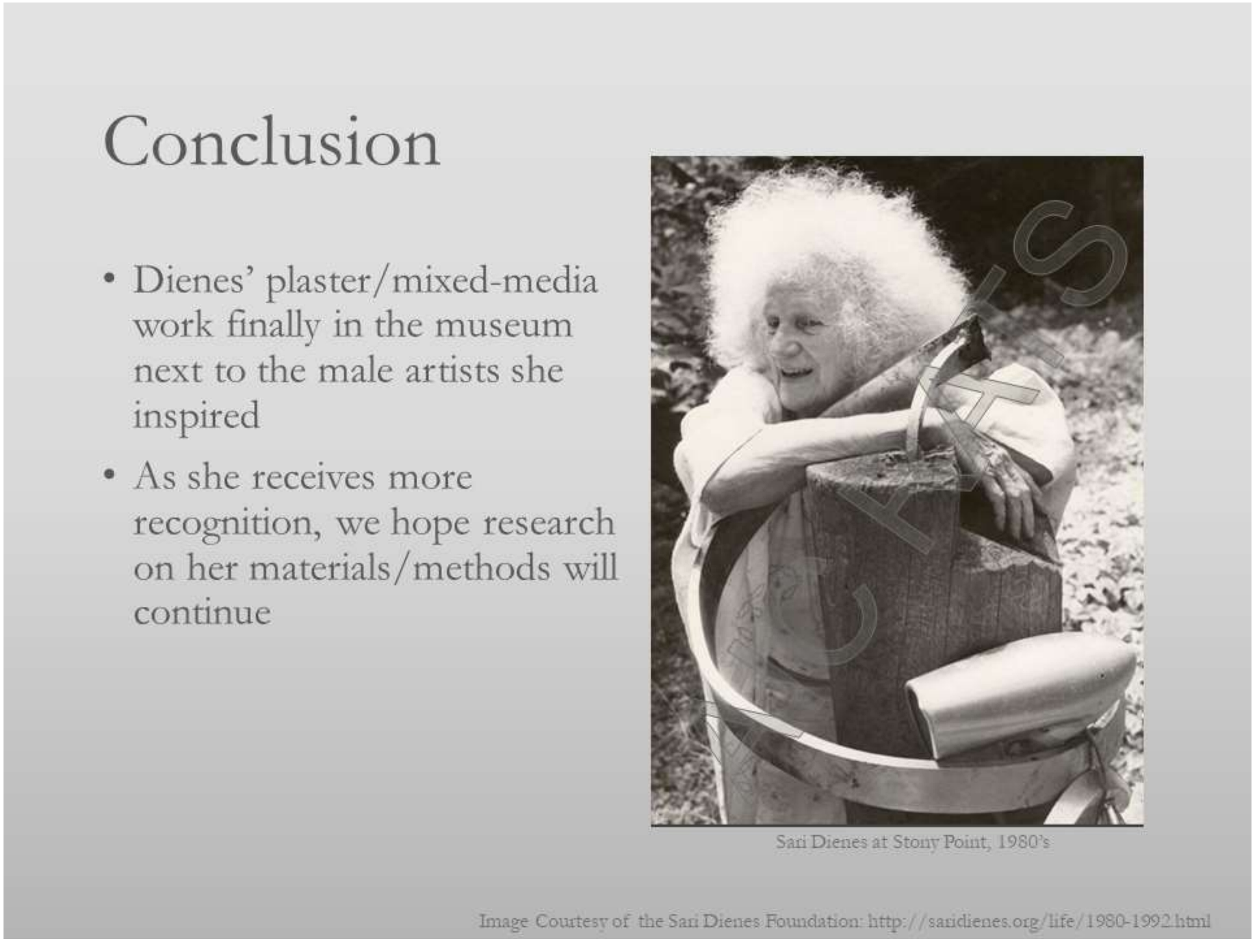
In order to stabilize the piece, the plan was to re-secure the foam board to a secondary support, both at the edges as well as behind the plaster cast near the center of the foam board, where most of the weight was pulling it down and away from the stretcher. While the idea of removing the board from the stretcher and securing it to another rigid secondary support was presented as an option, after discussion with the curator, it was determined that the stretcher was an integral component of the artwork and should therefore be kept in place. The curator also preferred to keep the staples that were visible on the front of the work in situ as the decision had clearly been made at some point to add additional hardware without removing the corroded staples. And when asked about the apparent repairs to these works, the foundation's curator Barbara Pollitt answered that they would have been carried out by Sari Dienes herself. The decision was therefore made to add an aluminum honeycomb panel at the interior of the stretcher rather than replace the stretcher entirely.

One of the first steps in treatment was to very carefully remove the foam board from the stretcher. As it turned out, most of the iron staples were not even contacting the wooden stretcher anymore and the piece was only held loosely to the support at three or four points. The aluminum honeycomb support was then secured inside the wooden stretcher and the sharp ends of the iron hardware on the reverse of the foam board were trimmed in preparation for re-mounting the board to the stretcher/aluminum honeycomb support.

To help support the weight of the plaster cast and take some of the stress off of the fragile edges of the foam board, several holes were drilled into the foam board behind the cast for stainless steel threaded inserts to be adhered into place. Corresponding holes were drilled into the aluminum honeycomb panel and the artwork and stretcher/aluminum honeycomb support were re-aligned and screwed together. This approach grew out of communications with the conservators at the Kunstmuseum Basel who had begun to consider options for treating their piece Snowflake Circle.

Four carbon fiber clips were then fabricated by VMFA mount maker Jim Heitchue, two for the bottom and one for each side. The clips were painted and screwed into the reverse of the aluminum panel, extending just enough around the edge of the piece to help hold the foam board in place. The clips are barely noticeable with the entire assembly screwed into the white shadow box frame. Star Circle was installed in the 20th century galleries at the VMFA in February 2019 and so far, the treatment appears to be successful.

Interestingly, the difference in thickness of the foam board support used in Snowflake Circle may guide treatment in a slightly different direction. As the 3/16" board has less structural stability on its own, the conservators in Basel are not planning to remove it from the stretcher, even temporarily. Instead, they plan to stabilize it by transferring the weight of the heavy plaster cast from the foam board to a secondary metal support. Securing the heavy plaster cast to a metal structure will relieve the shear stresses on the artwork, preventing the bowing of the foam board and possible failure of the bond between the plaster cast and the underlying support. Treatment has not yet begun on their piece as other projects with more pressing deadlines have taken priority.



While the treatment of Star Circle was a challenge, we are very happy to have it up in the gallery next to the male artists Dienes inspired. We hope that with the recent rediscovery of Sari's significance to the history of art, her work will enter more and more collections and the body of technical information on her materials and methods will continue grow.

We'd like to thank the many people who have helped out in this project- listed above.

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Colors of Jazz: Identification of the Colorants in Henri Matisse Gouaches Using a Noninvasive Approach

Ana Martins, Tiffany Tang, Abedalnour Haddad

In the last two decades of his extraordinary career, Henri Matisse created a remarkable body of work known as the Cut-Outs. He worked intensively with scissors and sheets of papers painted with vibrant gouaches, cutting shapes that he would then assemble to recreate lively figurative or abstract compositions. One of the earliest and most emblematic works of that period is the Jazz illustrated book published in 1947 by Tériade, a renowned editor of artist books in Paris. Matisse began creating the twenty circus themed cut-outs to be used as maquettes for the book in 1943. He insisted the vibrant colors of the cut-outs should be translated into the printed book, and this was ultimately achieved by the printer Vairel using Linel gouaches and the pochoir printing process. Hardly any information has been reported or published however about the composition of these particular gouaches or their properties, in particular their lightfastness; even though the artist himself was aware of the fragility of some of the colors like the pinks and the violets. In the preparation stages of a major exhibition at MoMA in 2014 dedicated to Henri Matisse: The Cut-Outs, the conservation department received the generous donation of a "reference set" of seventy nine samples taken from leftovers of original painted papers preserved by the artist's family and representing presumably the full range of colors he used. This set of reference samples was submitted to an exhaustive analysis to identify and characterize all the colorants present, to evaluate their lightfastness by microfading, and to build a reference library of spectral fingerprints acquired by XRF, FTIR, Raman, FT-Raman, SERS, ATR-FTIR, micro-FTIR, reflectance-FTIR and reflectance visible spectrophotometry. This study set is also being used to devise and validate a noninvasive protocol for the identification of the colorants in actual Cut-Outs. The current noninvasive methodology was applied to examine the nineteen different colors in the Jazz portfolio of twenty pochoirs in the MoMA collection. Most of the colorants present were identified successfully based on species or elemental markers detected by reflectance-FTIR, XRF analysis and spectrophotometry. Obtained results nevertheless reveal that a few of the colors that are repeated across different plates have the same tonality, but contain different colorants, suggesting that gouaches from different manufacturers were potentially used. Moreover, not all the gouaches in the Jazz portfolio could be matched to samples in the reference set, implying that it is incomplete. The reference spectral libraries compiled so far is therefore being expanded by studying other Cut-Outs in the MoMA collection and in other institutions, and by analyzing pure gouaches taken from paint tubes or paint brochures from the same period.

Constructivism Strands and Concrete Art in Brazil – the Materiality of Form

Luiz A C Souza, Maria Alice Castelo Branco, Yacy A. Froner, Giulia Giovani, Rita L. Rodrigues, Alessra Rosado

The aesthetics of Brazilian Concrete Art is characterized by visual and technical experimentations within the context of the post-2wwar conceptual-artistic relationship and the then contemporary "aura" of modernity, which was itself driven and supported by the industrial development in the country. The present paper presents the results of the research carried on the materials and technology of construction of paradigmatic works of art of the concretism period in Brazil, belonging to the following collections: Pinacoteca of the State of São Paulo; Museum of Modern Art – MAM – Rio de Janeiro; Collection Tuiuiú (onwed by Luis Antonio de Almeida Braga) – Rio de Janeiro; and the Pampulha Art Museum, in Belo Horizonte – Minas Gerais. The objects are studied under a methodological approach based on the principles of Technical Art History, as part of the J. Paul Getty Trust Project Pacific Standard Times – Los Angeles/Latin America – Getty PST LA/LA. The project partners are based in the USA – Getty Conservation Institute; Argentina – Universidad San Martin; Brazil – LACICOR – Conservation Science Laboratory, these last two with research grants kindly supported by the Getty Foundation The Brazilian Project Coordination is headed by the LACICOR – Conservation Science Laboratory team, based at CECOR – Center for Conservation of Cultural Heritage, at the School of Fine Arts of the Federal University of Minas Gerais, in Belo Horizonte, Minas Gerais, Brazil. At the School of Fine Arts, besides undergraduate courses in Arts, Fashion Design, Multimidia, Dance, and Conservation-Restoration Bachelor's Degree, we also have a Graduate (Master and Ph.D.) Program on Arts, with a research line in conservation of cultural heritage. The working methodological approach combines knowledge and traditional tools already used in the Art Historical research, with scientific methods of analysis of materials and scientific imaging documentation techniques. The results contribute to a better understanding of the historical, political, social and economic context of the creative period between the years 1950-60's in Brazil The case studies described represent original knowledge regarding the art production in Brazil at this specific period, 1950's - 1960, centered in the relations between matter and appearance, as well as involving the permanence in time of the works of art and the search for the most appropriate forms of access, exhibition and conservation-restoration processes. Diverse types of then "modern" binding media have been found by chemical analysis (PY-GC-MS, GC-MS, FTIR), such as nitrocellulose, alkyd, and PVA, as well as oil and oil-resin mixtures—including, in some cases, the use of beeswax as an extra component added to the main oil binding medium. Alkyd paints, for example, have been identified in fourteen out of a total of thirty-one paintings studied from these collections. For this presentation in particular we present the results of our studies on works by the following artists: Lygia Clark, Helio Oiticica, Waldemar Cordeiro, Judith Lauand, Willys de Castro, Hermelindo Fiaminghi, Ivan Serpa, Mauricio Nogueira de Lima, Aluisio Carvao, Milton da Costa.

Differential Stability of Cadmium Yellow Paints in Picasso's 'Femme'

Douglas MacLennan, Daniela Comelli, Markus Gross, Herant Khanjian, Joy Mazurek, Austin Nevin, Catherine Schmidt Patterson, Alan Phenix, Karen Trentelman, Gianluca Valentini

Pablo Picasso's 'Femme' (c. 1908; Beyeler Foundation, Basel, CH) is an oil study related to 'Les Demoiselles d'Avignon'. A collaborative, multi-analytical, technical examination of the painting was carried out to answer questions about the artist's materials and technique during an important, but relatively understudied, period of his career. Of particular technical interest were two yellow passages: a visibly degraded cool lemon yellow and a seemingly intact warm yellow. To understand the nature of the degradation, and to better assess the risk of further alteration, the physical structure of both yellow paints were assessed by visible-light and UV microscopy, and the chemical composition characterized by ESEM-EDS, GC-MS, and µFTIR. Although cadmium sulfide (CdS) and barium sulfate were present in both yellows, the overall elemental composition, size, and distribution of particles suggested two different commercial paint preparations. Visible-light and UV microscopy of prepared cross sections revealed a distinctive boundary between the altered lemon yellow paint towards the surface and an unaltered zone below. Detectably higher concentrations of known CdS alteration products - cadmium carbonate, cadmium sulfate, and cadmium oxalate - were identified by µFTIR in the altered region of the degraded lemon yellow paint. These results suggest the paint underwent photo-oxidative degradation, resulting in both a surface discoloration and the breakdown of the physical structure of the paint film. In contrast, the warm yellow paint samples showed no such evidence of deterioration. In order to map and better characterise the optical emission of the paint and its degradation additional analysis was carried out using in situ fluorescence lifetime imaging (FLIM) of the whole painting, and time-resolved photoluminescence microscopy of microsamples. Analysis revealed significant differences in the fluorescence decay, band gap, and trap state luminescence emissions between the intact and degraded cadmium sulfide yellow across the painting. The results enhance our understanding of degradation pathways present in Femme, which is expected to help guide the painting's future preservation. Moreover, data suggest that fluorescence lifetime imaging may provide a non-invasive mechanism for monitoring the state of preservation of cadmium sulfide painted layers.

The Human Endeavour: When Source Communities, Conservators and Scientists Collaborate

Nancy Odegaard

When science and material cultural heritage collaborate, the study may be called archaeometry, technical art history, conservation science, or taphonomy. The research may be about the artist's technique, tools, or component materials; or it may focus on specific techniques such as dating objects, non-destructive analysis; or it may be about the decomposition of materials during the period from deposition to discovery, or it may be focus on the predicting the future preservation risk to objects of art, archaeology, architecture. When conservators work with source communities, it may be called a consultation, collaboration, or contribution. The role of conservators and conservation scientists is very important. This presentation will share examples that illustrate their value when working with source communities under different circumstances.

Investigating Conservation Materials for Painted PMMA: Comparing Aging Environment Impact with Nano Thermal Analysis

Extended Abstract

Donald Sale*[1], Angelica Bartoletti[2,3], Laurent Bozec[3,4], and Marianne Odlyha[5]

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Key words: butyl methacrylate resins, crosslinking, glass transition temperature, Nano Thermal Analysis, Dynamic Load Thermal Mechanical Analysis, Paraloid B-67, Paraloid F-10

Butyl methacrylate (BMA) resins have been used by artists as varnishes since the 1930s. Their exceptional clarity, resistance to yellowing, solubility in aliphatic hydrocarbons, and working properties have also been recognized by art conservators, who have used BMA resins in treatments of oil paintings and poly(methyl methacrylate) or PMMA art and design. However, numerous studies since the 1950s have identified reduced solubility in aged BMA resins due to crosslinking. While these findings have led conservators to discontinue the use of BMA varnishes for oil paintings, these resins continue to be used for conservation treatments of PMMA, based in part on the assumption that they will remain soluble in aliphatic hydrocarbons after aging. BMA resins have also been proposed as conservation materials for acrylic paintings, and continue to be used as artists' varnishes.

This presentation describes an investigation of museum lighting impact on BMA resins proposed for conservation treatments of painted PMMA. Samples of 1:1 Paraloid B-67 (piBMA) / Paraloid F-10 (pnBMA) that had been exposed to UV filtered museum lighting (ambient artificial, accelerated artificial, or indoor sunlight) for approximately 16 weeks, were compared to thermal aged samples, and control samples kept in dark ambient conditions. After the initial comparative aging in 1992, the samples were naturally aged in dark ambient conditions for 23 years. Dynamic Load Thermal Mechanical Analysis (DLTMA) was used to characterize the sample-averaged glass transition temperature (Tg) of bulk BMA sample material, and Atomic Force Microscopy (AFM) based Nano Thermal Analysis (nano-TA) was used to investigate variations in the localized thermal response of the surfaces at sub-micron scale resolution, associated with crosslinking due to light exposure and aging.

Preliminary analysis revealed no apparent yellowing or molecular changes; however, Thermogravimetric Analysis (TGA) identified differences between the control sample kept in the dark and the samples exposed to light or thermal aging. In addition, DLTMA revealed a trend in the Tg of the bulk sample material, suggesting differences in crosslinking density related to the aging conditions. Moreover, nano-TA corroborated the trend of Tg associated with the aging conditions, but with subtle differences which suggest increased crosslinking density of the sample surfaces due to light exposure.

While further investigation is necessary, the trend in crosslinking density of these BMA samples suggests reduced solubility due to museum light exposure for a period equivalent to a temporary exhibition, followed by natural aging in dark ambient conditions. The sample exposed to ambient levels of artificial museum light for 16 weeks had a higher Tg than the dark-aged control sample. The sample exposed to UV filtered sunlight through a museum window for 14 weeks had a higher Tg than the sample exposed to an equivalent dose of artificial museum light after 16 weeks in an accelerated aging unit. These findings are compelling and may indicate that exposure to some museum light sources initiates crosslinking more rapidly than the literature suggests. Moreover, this information may influence the continued use of BMA resins as art conservation materials. Further, the apparent rate of crosslinking from museum light may have also identified a need to review preservation considerations for solvent sensitive acrylic paintings with artist applied BMA varnishes.

Nano-TA is useful for characterizing localized surface Tg associated with crosslinking of synthetic mediums due to the aging conditions, and differences between the surface Tg at nano-scale resolution and the sample-averaged Tg of bulk material. In contrast to complementary bulk thermal analysis, which involves lengthy procedures and comparatively large samples, the nano thermal probe enables rapid multiple and localized surface measurements, 40 in this study, without destroying the samples. Nano-TA appears useful for the identification of changes in thermal properties associated with environmental conditions, which influence conservation material selection and artist medium preservation.

Acknowledgements

I would like to thank the following institutions for funding this research and analysis: the J. Paul Getty Trust, Getty Conservation Institute for research and analysis including TGA and DLTMA, and the Getty Research Institute for research; the Eastman Dental Institute, University College London for Nano-TA; the Gabo Trust for presentation and travel funding to AIC Houston 2018, and for funding the initial 1992-95 study including materials to build the accelerated museum light aging unit, and the Tate Gallery for facilities for the initial 1992-95 study, and FTIR analysis and spectrophotometer access for color measurement. I would also like to thank my co-authors and the many individuals in these institutions for supporting this research, analysis, and presentation.

Tracing Back: How Trace Elements in Smalt and Ultramarine Used by 17th Century Dutch Artist Jan Steen, Start to Shed Light on the Chronology of His Oeuvre

Sabrina Meloni, Ralph Haswell, Annelies van Loon, Onno de Noord

Jan Steen (c. 1625-1679) is one of the best-known artists of the Dutch Golden Age. Although he painted many different subjects, he is most famous for his genre paintings with merry companies. One key feature of his extensive oeuvre remains elusive: its chronology. Only 10% of his works were dated by the artist. Steen was prolific, he worked in different cities, and his painting style and techniques varied. This has made dating his paintings complex and problematic. Jan Steen's oeuvre of about 400 paintings provides a unique opportunity to mesh traditional art history with new investigative techniques to reconstruct the chronology of his work and gain more insight into the materials and techniques he used over the years. The research started with the fifteen paintings by Jan Steen in the collection of the Mauritshuis. They are nicely spread out over the years that Jan Steen has been active. This group of paintings is enlarged with researching dated paintings in his oeuvre from other collections, with the aim of using these as a marker for the rest of his oeuvre. So far 37 paintings by Jan Steen have been studied in depth. This number is still growing, and complemented with the study of paintings by his contemporaries from the cities where he worked. Our hypothesis is that he influenced, and was influenced by the artists around him, and that he may have adapted his materials and techniques to local artistic traditions. In addition to the infrared photos and X-rays, a small number of paint samples have been taken from the paintings, and analyzed with SEM-EDX. Various point measurements have been carried out and for all the cross-sections elemental maps have been created. While it was initially thought that studying the color and pigment composition of his ground layers might shed a light on the city in which the paintings where executed and hence give it a place in the chronology of his oeuvre, the focus has shifted during the research. Next to the study of the ground layers, certain pigments in his paint layers are now studied in more depth. By looking at trace elements in his blue pigments, like smalt and ultramarine, two pigments Steen used a lot, we found some promising results considering the chronology. A rather new tool in the study of paintings to get more information out a large number of data is the use of a statistical database. By doing multivariate analyses on a chosen data set the correlation between variables can be found which without this analyses will be overlooked. For Jan Steen paintings it turned out that by putting the trace elements found in the pigment smalt he has used, but also the smalt used by contemporaries, in a statistical database, clusters of paintings were formed after the multivariate analyses, which could be correlated to the cities where he worked. These results are very promising and give already more insight into the chronology of his work. This research will now be extended with his use of ultramarine.

The Use of Nano-Indentation to Mechanically Characterize Embedded Artists' Materials

Ashley Freeman, Vincent L. Beltran, Michał Lukomski

The Managing Collection Environments initiative at the Getty Conservation Institute focuses on research questions and practical issues relating to the control and management of collection environments in museums. Providing an evidence-base for the effect of environmental conditions on historic materials has long been a challenge for the conservation field, due to both the inherent complexity of the materials and the uncertainty in the mechanisms at play in environmentally-induced change. Understanding the mechanical properties of cultural heritage materials is a fundamental aspect of establishing effective preservation methods. Conventionally, the mechanical characterization of artists' materials is performed by uniaxial or biaxial tensile testing and typically requires a large quantity of macro-sized samples. Having access to sufficient numbers of historic materials that satisfy this sample size requirement is impractical if not impossible when working with museum collections. As a consequence, the applicability of macro-mechanical testing in the conservation science can be limited. In contrast, small scale engineering techniques such as micro- and nano-indentation allow for the characterization of sub-millimeter samples taken from real works of art, rather than relying wholly upon much larger laboratory-prepared samples intended to mimic historic materials. These engineering techniques open a new perspective on the systematic analysis of the probabilistic distribution of mechanical properties of artists' materials. They also allow for the analysis of ageing factors which can alter the mechanical properties of a material. The primary focus of this study is the application of micro- and nano-indentation to investigate the effect of an embedding process on the mechanical properties of cross-sectional samples of acrylic-based paint. As a precursor to the analysis of historic samples, a systematic investigation of embedded samples was performed to assess the role of sample size, surface roughness and structural compliance of the embedding resin. Material characterization was conducted at ambient laboratory conditions using an Ultra-High Resolution Nanoindentation Tester (Anton Paar) equipped with a Berkovich (three-sided pyramidal) diamond indenter. Load–displacement tests were carried out on embedded and free-film samples to evaluate the quasi-static and dynamic behavior of the acrylic-based paint to better understand its deformation response. Mechanical parameters which are used for describing the stiffness of a material, such as the elastic behavior of a material (storage modulus) and the ability of the material to deform under constant load (creep), were obtained for cross-sectional samples and compared with results for the acrylic free-film. Results indicate that instrumented indentation can be successfully used as a stepping stone towards an improved understanding of mechanical properties of embedded artists' materials and, consequently, allow one to better define the conservation needs of art objects.

2018 – Research and Technical Studies and Textiles Specialty Group Presentations

Some of the joint Research and Technical Studies/Textiles Specialty Group Presentations were published in the Wooden Artifacts Group Postprints. Wooden Artifacts Group Postprints is published annually by the Wooden Artifacts Specialty Group (WAG) of the American Institute for Conservation of Historic & Artistic Works (AIC). A membership benefit of the Wooden Artifacts Group, Wooden Artifacts Group Postprints is mainly comprised of papers presented at WAG sessions at AIC Annual Meetings and is intended to inform and educate conservation-related disciplines. These postprints are not duplicated here, rather the abstracts from the joint session are included. The full WAG 2018 postprints are available for purchase on the AIC website.

Fiber and Yarn Cross-Section Sample Preparation Methods for Effective Plant Fiber Material Characterization and Identification

Runying Chen, Tom Fink

Fiber cross-section observation is often essential when characterizing and identifying plant fiber artifacts. A number of bast fibers and leaf fibers have very similar morphologies in the longitudinal direction but they differ more distinctively from each other in cross-section features. Most of the existing methods of fiber or yarn cross-section sample preparation, for either light or scanning electron microscopic (SEM) observations, are not designed for handling fragile archaeological materials. The aim of this research project was to identify and develop effective fiber or yarn cross-section preparation methods which can be used for studying fragile archaeological textile objects. This study compared three fiber or yarn cross-section sample preparation methods for SEM observation including epoxy embedding, modified plastic fiber cross-section plate and free-hand as well as another three methods for light microscopic (LM) observation, including epoxy embedding and ultra-thin cross-sectioning, free-hand sectioning of embedded fiber or yarn sample and Precision Cross-section Microtome. All these methods were applied to the same archaeological textile remains retrieved from an early 16th century shipwreck site. Several known fiber or fiber plant samples were also studied for reference purposes, including hemp, jute, sisal, abaca, stinging nettle and flax. The SEM results showed that the adoption of a plastic cross-section plate designed for LM usage was the most effective fiber or yarn cross-section preparation method. The plate is cheap and easy to use. Either fiber or yarn samples can be placed into the 1-2 mm holes within the plastic plate using a known synthetic fiber as buffer or protection around the archaeological fiber sample. As to the three methods for LM observation, the most efficient method was free-hand sectioning of fiber or yarn embedded in common slide preparation solution. When dealing with very fragile sample, however, the best method was epoxy resin embedding and ultra-thin cross-sectioning (1 micrometer). This method minimizes sample distortion and keeps the sample intact. However, a phase contrast microscope is needed for observing and imaging the obtained ultra-thin cross-section samples. Based on all the cross-section images obtained from both archaeological textile samples and reference fibers or fiber plant samples, we recommend using yarns to prepare cross-section sample for either SEM or LM observation when possible. The cross-section of yarns could provide not only fiber information but also other plant tissue cell characteristics. The later can be critical when identifying a specific fiber plant. When studying very fragile archaeological textile material, we recommend the method of epoxy embedding and ultra-thin sectioning, although this method is most time consuming. The other two methods using plastic fiber cross-section plate for SEM observation and free-hand sectioning of embedded sample for LM observation are quick, easy, effective and applicable to most of textile materials. Finally, the results of this project demonstrated again that fiber cross-section study is essential when identifying and characterizing archaeological plant fiber artifacts.

The full postprint of this talk is available in the 2018 WAG Postprints, available for purchase on the AIC website.

The Norwich Textile Reference Database, A Collections Care Project

Jocelyn Alcantara Garcia, Michael Nix

The city of Norwich, United Kingdom still produces beautiful and high-quality woolen textiles, although its heyday was between the 14th and 19th centuries. As a result of this active textile industry, garments and fabrics are found in numerous textile collections around the globe. In spite of its importance, information regarding dyes, mordants and technologies associated with dying practices in the city remain scarce. During the second half of the 18th century, when the trade of raw materials and finished goods was commonplace, merchant manufacturers used pattern books and cards containing textile swatches to facilitate sales and trade. Some of these outstandingly well-preserved pattern books survive. After thorough ethical conversations, a dye-and-mordant database incorporating chromatographic and spectroscopic data is being generated using samples from these pattern books. High-performance liquid chromatography – photodiode array detector (HPLC-PDA) in conjunction with X-ray fluorescence (XRF), has allowed us to identify distinctive dye and mordant combinations, which, in parallel with collaborative historical and archival research, is aiding in understanding the industry's practices. More importantly, this will ultimately support collections care by providing sound scientific information related to textiles' constituent material properties, such as light and moisture sensitivity of certain color components.

The full postprint of this talk is available in the 2018 WAG Postprints, available for purchase on the AIC website.

Roundtable Discussion

Mary W. Ballard, Nancy Odegaard, Margaret T. Ordoñez, Gwen Spicer

When TSG and RATS began planning a joint session for the 2018 annual meeting, we met with some resistance because AIC records suggested that there were no individuals who were members of both specialty groups. We've learned since that this is both not true (two of our panelists are members of both) and it's definitely not the case that no one in TSG is doing research, nor because no conservation scientists are interested in textiles. But how can we increase the interactions and strengthen ties between our two groups?

In this panel discussion you will hear from a conservator in a major museum, a current professor, a retired professor and a conservator in private practice. Each will bring a different approach to this topic and offer advice and anecdotes on how they bridge the gap between research and textiles in their profession. Topics of discussion will include: what makes for a good and successful research project? Do all projects have to involve big questions and fancy scientific equipment? How can keeping an open mind, and questioning assumptions lead to new discoveries? What makes projects work? What makes projects not work? We hope that this panel will help our communities forge connections, learn from successes and failures and encourage each other. Audience participation in the form of an open question and answer session will follow.

Panelists:

- Dr. Margaret Ordoñez, Professor Emerita, Textiles, Fashion Merchandising, and Design, University of Rhode Island; Conservator, Ordoñez Textile Conservation Services, Camden, TN
- Mary W. Ballard, Museum Conservation Institute, Smithsonian Institution, Senior Textiles Conservator, Suitland, Maryland
- Gwen Spicer, Spicer Art Conservation, LLC
- Dr. Nancy Odegaard, Conservator, Head of Preservation Division, Arizona State Museum; Professor, Department of Materials Science & Engineering, School of Anthropology, American Indian Studies GIDP, University of Arizona, Tucson, AZ

A Sizable Sooty Soiled Surface: Analyzing and Evaluating Methods for Surface Cleaning a Large Painted Muslin

Susan Heald, Nora Frankel, Gwénaëlle Kavich, Thomas Lam, Nicole Litte, Annaick Parker, Megan Doxy Whitfield

Throughout the documentation and treatment of an unusually large painted muslin, analytical methods helped to both characterize the object, and evaluate the efficacy of the treatment. Displayed at the 1893 Chicago World's Fair, the muslin painted by Strike the Kettle (Lakota), a follower of Sitting Bull, depicts multiple scenes including gift giving, cooking, and warriors on horseback. The muslin was treated for the major long-term exhibition, Americans, at the National Museum of the American Indian. Previous extended display in the industrial urban centers of Chicago and New York City resulted in heavy, sooty, lead-containing surface soiling. Prominent tar-like stains in the center had haloed tidelines from an earlier treatment attempt. Pigments, binder, and stain residue were characterized using microscopy, portable x-ray fluorescence spectroscopy (pXRF), attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR), microscope-FTIR, and x-ray diffraction (XRD). Analyses confirmed that common late 19th century trade pigments were used with a proteinaceous binder. All paint colors were evaluated for light stability using microfadeometry, revealing all but one were stable. The black stain was characterized as an oily resinous compound with surprisingly high lead levels. The treatment priority was to reduce the stain and its associated tideline, and disfiguring surface soiling. Vacuuming the muslin through Vellux fabric trapped significant soiling, however the visual impact was minimal requiring additional dry cleaning treatment. Of the four sponges evaluated, the vulcanized rubber soot sponge was most effective though somewhat abrasive based on cleaning tests, microscopy, FTIR, and pXRF. The need for multiple hands working simultaneously over a large surface area necessitated a systematic approach to ensure consistency. This cleaning methodology produced large quantities of heavily soiled Vellux and sponges, allowing for a thorough study of cleaning mechanisms and soiling characteristics. While the tar-like stain responded poorly to all solvents tested, ethanol and a suction platen successfully reduced the tidelines created by the previous treatment. The treatment methods dramatically improved the muslin's appearance. Final pXRF analyses indicated the soot sponge was more effective at reducing overall lead levels than the use of a Vellux-covered vacuum alone. Portable XRF also detected lead levels on the used Vellux and soot sponges, but not the nitrile gloves, which had implications for material disposal as potential hazardous waste.

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Untangling Indian Hemp: Understanding and Identifying Common Plant Fibers Used by Native Americans in the Woodlands Region

Nora Frankel, Susan Heald, Thomas Lam

Bast fibers from North American plant species make up a significant portion of textiles produced by Woodlands cultures. These fibers, which are derived from the inner stems of certain plant species, are a traditional and important to many nations in the Northeast and Great Lakes region, yet have received little attention from Western-focused academia. Much of the literature and fiber identification is unclear, incorrect, or based on a Western perspective. Fibers are frequently referred to as "Indian Hemp," which aside from being an inherently problematic term, has several meanings. This research aims to collaborate with Indigenous community members to identify traditional fiber producing plants and how they utilized to produce textiles. Three Native American experts in fiber preparation were invited to the National Museum of the American Indian Cultural Resource Center to share and discuss harvesting, processing and weaving, as well as the cultural and material significance of these fibers. As an outcome, a handling collection of physical samples as well as polarized light and scanning electron micrographs will be created to aid in understanding of both the macro and micro properties of these materials. The reference collections and appropriate associated cultural information are available to conservators, curators, and Native and non-Native researchers to improve accuracy of fiber identification, enhance material understanding, and reinforce cultural knowledge. Images will also be made available on online for wider access. By understanding both the physical and cultural context of materials, conservators can make more appropriate decisions about the care of our collections. Allowing indigenous voices to be the authority on their own cultural heritage not only begins the decolonization process of museums, but enriches the institution as well.

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2018 – Research and Technical Studies and Wooden Objects Specialty Group Presentations

Wooden Artifacts Group Postprints is published annually by the Wooden Artifacts Specialty Group (WAG) of the American Institute for Conservation of Historic & Artistic Works (AIC). A membership benefit of the Wooden Artifacts Group, Wooden Artifacts Group Postprints is mainly comprised of papers presented at WAG sessions at AIC Annual Meetings and is intended to inform and educate conservation-related disciplines. These postprints are not duplicated here, rather the abstracts from the joint session are included. The postprints of the WAG session are available for purchase on the AIC website.

All that Glitters: Visualizing and Characterizing Gold Leaf through Macro-XRF Scanning

Douglas MacLennan, Nathan Daly, Arlen Heginbotham, Lynn Lee, Catherine Schmidt Patterson, Yvonne Szafran, Karen Trentelman, Nancy Turner

The application of gold leaf is ubiquitous in late medieval painting, but our knowledge of how it was applied is based largely on historical treatises and modern practice. Analytical techniques traditionally applied to the study of historic works of art, such as X-radiography and point-analysis x-ray fluorescence (XRF), identify only the presence and elemental composition of the metal leaf at a single point, respectively. MA-XRF scanning has opened up a new avenue of research into the study of gilding materials and techniques by providing unprecedented new insight into visualizing the dimensions of individual gold leaves, differences in how the leaf was applied by various artists and workshops, and the variability of gold leaf alloy compositions available. In addition to elucidating the original artistic creative process, MA-XRF can identify and map restoration interventions using gold leaf, thereby providing new documentation of historic conservation or restoration efforts. Statistical measurement of the dimensions of individual gold leaves provides a new tool for supporting or refuting links between separated components of altarpieces. This poster presents the results of studies from a number of paintings and manuscript illuminations that demonstrate the ability of MA-XRF to elucidate new information about the composition of metal leaf, its application, and its past conservation.

Another Look at Conserving a Japanned High Chest

Christopher Swan, Kirsten Moffit

A growing awareness of East Asian influence in our Western world has spurred a reconsideration of many of the rare American Japanned objects from the first half of the 18th century. Among these is a sometimes celebrated high chest in the Art Museums collection at the Colonial Williamsburg Foundation (CWF). One of only about 15 such Japanned forms known, the bulk of the artistic merit of the cabinet lies in the decoration attributed to Robert Davis of Boston, around the 1730's. Because the iconography of these—mainly Boston made—Japanned objects continues to be something of a mystery among many decorative arts scholars, the material make up has become the obvious necessary foundation to our understanding of such mannerist artistic expressions. In this paper the CWF high chest is presented with an eye toward understanding the original materials and design intent, as well as the reinterpretation of some of these lost and poorly restored elements. Like many of its cousins, this Japanned cabinet has seen several campaigns of restoration in its lifetime. With time, the raised ornament seems to have failed in many of these surfaces and the multiple restorations appear to have veered further from the maker's vision with each campaign. Some attention will be paid to the choices of material and technique in the restorative process as well. The study and analyses that preceded the on-going treatment featured photography with visible light, ultra-violet, Infra-red, and x-ray. Analyses for materials identification featured X-ray fluorescence spectroscopy, FTIR spectroscopy, SEM with EDX, and visible and fluorescence cross-section microscopy. Combining the findings from these analytical techniques has provided a fairly comprehensive picture of the materials in the surface decoration. They have also revealed a few surprises in makeup, as well as a much-needed road map for the treatment protocol. The project reflects a vital collaboration between the CWF Analytical Lab and Wood Artifacts Lab. Insights gleaned from this exploration and treatment will hopefully inspire other owners to reconsider their objects with the hope of new exhibits and a better understanding of interpretation.

Bringing Back Color: Retouching Faded Furniture with Colored Light

Maarten R. van Bommel, Federica van Adrichem, Jaap Boonstra

Throughout the centuries organic colorants, both from natural and synthetic origin, were used to stain wood. This application lead to vivid colored objects of which the wood texture is still visible. Colorants can be applied over the complete surface of an object or used especially for marquetry, resulting in multi-colored objects. In addition to the coloring of wood, the natural color of unstained wood plays also an important role in the overall appearance of furniture. The main disadvantage of the use of organic colorants is the fact that they can severely fade in time, this is also true for the natural color of wood. As a consequence, the original appearance is lost to such extent that many museum visitors are not even aware of the fact that numerous pieces of furniture were originally colored; the visitors appreciate the natural, discolored wood and knowledge of how these objects originally looked like is sometimes completely ignored. To obtain knowledge about the original appearance is a great challenge, and it is good to realize that we will never be able to get the 'exact' colors right. However, more insight is required to be able to come as close as possible to the original intention of the makers of these objects. To revive this knowledge is only possible with an integrated approach. With this presentation, this integrated approach will be discussed. The research involves chemical analysis of the faded material, which is a challenge on its own, to identify the colorants used. The next step is the study of historical recipes and the creation of reconstructions (small mock-ups) based on these recipes to obtain more knowledge of the range of colors possible with the materials used. Degradation research is carried out on some of these colorants to understand their behavior. Finally, faded pieces of furniture were retouched using colored light, projecting a computer image via a beamer on the object in which the faded colors were revived. Although a promising technique, with possibilities to show these original vibrant objects to a large audience, questions arise about the accuracy of the reconstructed colors and the possible change in artistic value. However, it stimulates the discussion between curators, conservators and scientists about the possibilities and limitation of this technique and how to present the objects to the museum audience. Two case studies will be discussed. A group of objects designed by the Dutch architect Piet Kramer in the 1930's which were originally stained with brilliant synthetic dyes and are now heavily discolored were accurately examined and these results will be presented. In addition, preliminary results will be discussed about the retouching of a much more complicated 18th century commode created by Andries Bongen.

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A Contribution toward the Identification of Wood by Heart-Cut Pyrolysis Gas Chromatography Mass Spectrometry

Arlen Heginbotham, Jessica Chasen, Michael R. Schilling

This paper presents a novel method for conducting wood identification based on chemical analysis using heart-cut pyrolysis gas chromatography/mass spectrometry (HC-Py-GC/MS) to analyze volatile fractions and thermal decomposition products from finely divided wood samples. This method has several advantages over traditional anatomical identification including a significantly reduced sample size (0.3 mg of powder vs. more than 40 mg for traditional thin anatomical sections), and increased ease of sampling. The method also shows promise for successfully discriminating between species that are not separable by anatomical methods. The use of an established analytical technique that is widely found in conservation science laboratories should make this method readily accessible to many researchers in the cultural heritage sector. The use of user-friendly and commercially available software for the evaluation of the GC/MS data also makes it possible to develop a reference database that can be easily shared and referenced by collaborating researchers. Evolved gas analysis (EGA) was used to establish an optimized furnace temperature that minimizes the production of compounds from the pyrolysis of cellulose and hemicellulose while maximizing the contribution of non-cellulosic components such as lignin and extractives, which are more likely to be characteristic of specific species. The use of a selective sampler system further reduces cellulosic contributions to the chromatograms by diverting evolved gases away from the GC column after 30 seconds of sample residence in the pyrolyzer. Results were interpreted through comparison with reference standards utilizing F-Search from Frontier Laboratories, which is software commonly used for the identification of polymeric materials and additives in plastics. The software produces a weighted average of the mass spectra of all integrated components in a chromatogram (an INT-SUM spectrum), which can be matched against an established library of standards. Comparison of the chromatograms and statistical evaluation of the INT-SUM spectra by F-Search provided accurate results and eliminated the need for specific compound identification, thus rapidly increasing the speed of data interpretation. F-Search also allows for the exclusion of peaks, which is a feature used to eliminate problematic peaks produced by contaminants such as glues, varnishes or waxes. For this preliminary study, reference samples of 62 wood species commonly found in decorative arts collections were analyzed with the optimized HC-Py-GC/MS method. The resulting chromatograms and INT-SUM spectra were compiled in a reference library. The method was validated by analyzing samples taken from 17th – 19th century objects within the J. Paul Getty Museum collection and comparing the results to identifications made through traditional anatomical study. All of the samples were correctly identified through the combined use of the F-search ranking system and visual comparison of the chromatograms.

Interdisciplinary and Multi-Technique Study of Previous Conservation, Bending Media, and Pigments of a Painted Polychrome Coffin from the Late Period

M. Moustafa, Medhat Abdallah, Ahmed Abdrabou, Hussein M. Kamal

This paper describes the scientific investigations of an Ancient Egyptian painted wooden coffin, dating back to late period (664-332 BC). The polychrome coffin was previously restored, and previous plaster fills obscured original surface. The focus of this study is to use a multi-analytical approach to map and identify the pigments used on a polychrome wooden coffin , as well as to provide a deeper understanding of the painting techniques, the condition of the object, identification of wood species, identification of insects founded inside coffin, previous conservation materials, ground layer and painted layer included in this study. Several analytical and observation methods were employed in the identification processes such as the Light optical microscopy (OM), X-ray fluorescence portable (XRF), X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR). Moreover, the application of technical photography provided useful information about the spatial distribution of the surviving original pigments, in particular visible-induced luminescence, which played an important role to recognize spatial distribution of areas containing Egyptian blue, even if it is in traces or mixed with other pigments, the authors were significantly interested in mapping technical photography (TP) including IR false color with XRF results as a non destructive methods to identify coffin pigments. Red pigment identified as Cinnabar, and recorded as a rare pigment found in late period collections. Key words: painted wooden coffin; Multispectral imaging; XRF; wood identification; Cinnabar

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