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Abstracts presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

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KATHRYN BOODLE

Where Tradition Meets Technology: Utilizing Microfibrillated Cellulose (MFC) as a Reinforcement Material in Fan Conservation

INTRODUCTION

In recent years, the conservation field has seen a rise in the use of nanocellulose as a viable solution for fine repair of heritage materials. The ability to cast thin, translucent sheets of nanocellulose either alone or imbued with an adhesive makes them a good alternative for repair on semi-translucent substrates or double-sided objects. As with any technique that utilizes near invisible repairs (e.g., fine fiber stitch [Miller 2010]), they take practice to use and are helpful in specific situations, but should not be viewed as a total replacement for traditional mending. There are some situations where the merging of nanocellulose with traditional methodology can be beneficial and play off the strengths of all materials for the improved life of the object.

While the catch-all term for the material tends to be known colloquially as nanocellulose, this term may refer to materials that are broken down to the microfibril or nanofibril size during processing (Dreyfuss-Deseigne 2017b). In the available literature, nanocellulose may also be referred to as microfibrillated cellulose (MFC), nanofibrillated cellulose (NFC), cellulose nanocrystals (CNC), bacteria cellulose (BC), etc., in an effort to more specifically identify the source material used to create it and the process by which it was formed (Dreyfuss-Deseigne 2017b; Dreyfuss-Deseigne 2018). The various types of nanocellulose available for conservation all have their pros and cons depending on the final result desired by the treatment. Rather than discussing the various differences between available nanocelluloses, this article will focus on MFC and examine its use in the treatment of three paper fans.

MFC is composed of cellulose chains that have had their hydrogen bonds forcibly separated by a mechanical process and put in an aqueous suspension to retain a few cellulose compound units linked together in a dispersion. This dispersion consists of long, flexible entangled fibers containing both crystalline and amorphous regions, providing both flexibility and strength to the cast film used in treatment. After processing to the microfibril level, these fibrils are between 5–30 nm in diameter and an average of 1–3 μm in length. This can vary based on the original source material and how the cellulose was processed. The source materials that can be used to create MFC can be a variety of plants: softwood, hardwood, bamboo, cotton, linen, etc. Impurities from wood, such as lignin or hemicellulose, are removed prior to or during the processing of the material to ensure stability (Dreyfuss-Deseigne 2017a; Dreyfuss-Deseigne 2017b). The 2.6% Celova Nanogel, manufactured by Weidmann Fiber Technology, was selected for this project as it was easy to acquire, budget friendly, and easy to manipulate in its gel form.

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

FAN CONSERVATION: TREATMENT APPROACHES AND LIMITATIONS

Before delving more deeply into the use of MFC with traditional mends, it is important to understand the construction of a fan and how preserving its functionality can limit treatment options. Fans are made of wooden sticks that are joined together at the head by a rivet. These sticks usually narrow at the point where they enter the fan package, becoming the ribs or slips (Maxson 1986). The fan package is made of two separate sheets of paper sealed at the top edge with a ribbon made of paper (or fabric) that helps hold the paper together when the individual fan leaves are folded for movement. The fan papers are attached to the inserted ribs with adhesive rather than to each other, which creates a series of air pockets around the ribs and on the non-adhered leaves (fig. 1). This localized attachment and air pocket network is crucial to the fan's ability to function and move. The fan is protected when closed by two wooden guards at either end, which are usually thicker than the sticks and polished or lacquered depending on the design. The guards help to both keep the fan closed and aligned, while acting as a lever when opening the fan (Maxson 1986).

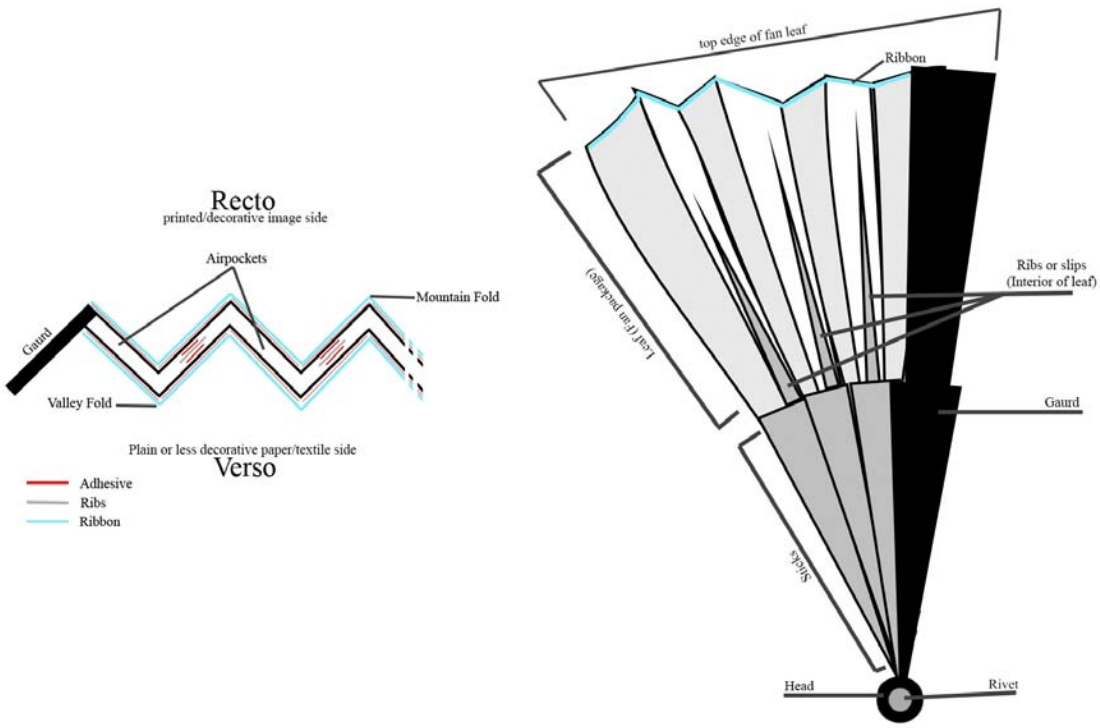

Fig. 1. Diagram illustrating the interior attachment of the fan ribs to the paper package (left) that need to be preserved during mending and the parts of a fan overall (right).

Unless the fan is completely deconstructed for aqueous or intensive stabilizing treatment due to extensive damage, the conservator must work in a limited space and utilize protective methods to preserve the air pockets in the fan packet. If space permits, polyester strips can be used to help insert repair tissues between the recto and verso papers. The polyester helps preserve the air pockets within the fan leaves by ensuring the repair paper only adheres to one side of the fan packet. Given the rigidity of the heavier polyesters (i.e., 4 or 5 mil), there may be a risk of exacerbating the tear along the mountain and valley folds with this method. As an alternative, silicone release paper or film may be used as it can be easier to shape and insert given its thinness and flexibility in comparison. The protective support, be it polyester or silicone release film, needs to have a section that extends beyond the edge of the fan papers so that it can be removed easily once the repair is fully dry. Since these protective supports block moisture and prevent adhesion of the repair to maintain the air pockets within the fan leaves, drier adhesives and desiccated blotters should also be used when applying the repair to avoid tidelines along the folds.

Another factor for consideration with the treatment of fans is how much the added thickness of the repair may affect folds and the function of the fan post-treatment, much like when guarding a bound volume and monitoring for swelling of the spine. A thinner repair tissue is better as it reduces undesirable structural change to the fan, but it can be challenging to apply cleanly to the repair area when visually it is not easily discernible from the protective support described above. Minor stress testing of the area by opening and closing the fan after drying is one of the few ways to confirm correct adhesion and repair.

A final note in preparing for treatment is to take into account the overall support of the fan during repair. During this phase, the fan needs to be supported so that the folds are preserved while providing a strong base for the repairs to be dried under weight. Custom supports of 4-ply rag board that mimic the mountain peaks of the fans were used during treatment in the case study, with dowels to control the height and movement of the supports (fig. 2). These supports were critical for maintaining not just the folds, but also paper alignment during mending. Snake weights helped to hold the object in place though heavier bag weights were also utilized to set the repair tissue. The amount of weight needed to set each repair varied and, as for many paper-based items, was largely based on the thickness and quality of the primary substrate. For example, with the fans in the case study, the recto paper was a thicker good to moderate quality paper used for lithographic printing while the verso paper was a thin decorative lacquer-like paper of poor quality. While the lithographic paper was repaired with an 11 gsm kozo that needed bag weights to be fully affixed, the black lacquer-like paper needed a 5 gsm kozo

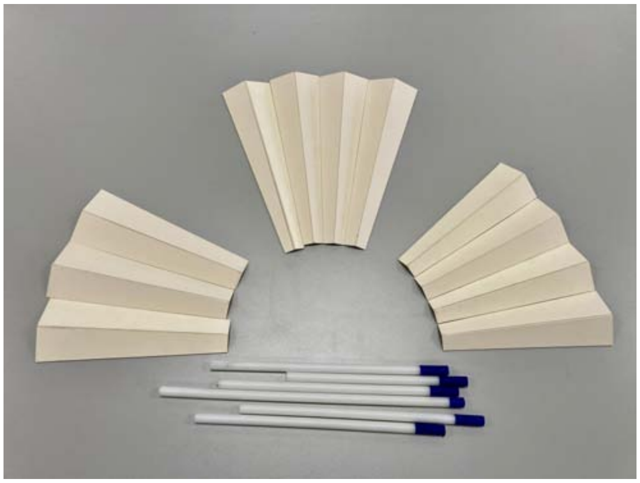

Fig. 2. Support pieces and dowels used during conservation treatment.

with only the snake weights due to its thinness, although it did require tighter control of moisture and was less forgiving of mistakes for similar reasons.

Overall, when treating a fan for repair using Japanese tissue paper, it is important to note that there will be significant paper manipulation within a very compact area. This takes time to complete as one should not work on adjacent folds at the same time and must wait for each area to fully dry before testing the repair and continuing. Working in this manner will avoid stressing the piece unnecessarily, limit the duration under which folded areas are weighted during repair, and preserve the fan folds.

TESTING WITH CELOVA NANOGEL FOR LOCAL REPAIR

Conservators may be familiar with the work by Remy Dreyfuss-Deseigne on casting MFC into films for nearly invisible repairs on transparent or semi-transparent papers. While these films have several benefits, a cast MFC film for repair of the fans was only briefly considered as a viable treatment alternative to traditional mending. After initial tests on mock ups, several points of concern arose for using this method on the actual object. First, when inserted into the fan package, it still required a comparable level of manipulation to mend the tears as when using a Japanese tissue. As such, this would not eliminate any of the treatment concerns or improve handling of the damaged areas in a meaningful way. Second, if the film was applied on top of the torn or split areas, it would still be visible in certain lighting. Additionally, while testing was only conducted on blank paper, there were concerns that a repair applied on top of the actual object could cause media discoloration or local tidelines. Lastly, if the strip was applied on top, there was concern around how the cast film would withstand the movement required to allow the fan to open and close. Since there is not much information available on nanocellulose films being flexed, it was uncertain whether the repair would either fail too easily over time or be too durable and cause breaks in the paper when manipulated. In consideration of the above concerns and the time required to create and apply cast MFC films correctly, it appeared that cast MFC films would not be optimal for use on three-dimensional objects that need to move semi-frequently.

While the use of MFC as a cast film was of little interest for the purposes of fan treatment for the reasons above, it was also discovered that MFC can also be applied directly to an object in its gel form to form a local mend. Rémy Dreyfuss-Deseigne mentioned this repair method of direct application in passing during the FAIC-hosted workshop, "Applications in Nanocellulose Films in Conservation," held at the Museum of Fine Arts, Boston in July of 2018. He explained that MFC reestablishes strong hydrogen bonding within the fibrils of the cellulose matrix as it dries, which in turn allows it to also form hydrogen bonds with the cellulose of the paper it has been applied to (Maloney 2019). No further explanation or experimentation of this method was done during the workshop as its primary focus was on cast films. Based on this anecdotal information, it was believed that the direct application of MFC in gel form had potential to limit stress and manipulation of the fan in areas of minor or partial breaks along the fold lines without compromising the overall fan package. Since a search of the available literature did not yield additional information on methodology,[1] testing was carried out on samples to see if it was a feasible option for at least some, if not all, of the fan repair areas.

Weidmann Fiber Technology's Celova Nanogel is available in concentrations of 3%, 10%, and 30%, although the exact concentration in each order may vary slightly. The container of Nanogel that was ordered by NEDCC was marked at a concentration of 2.6% (fig. 3). On Weidmann's website,

Fig. 3. 2.6% Celova® Nanogel used during treatment.

the 3% is listed as "microfibrillated cellulose in suspension" and is much closer to a gel than the 10% and 30% which are powdery and advertised as a "microfibrillated cellulose paste" ("Celova" 2019; "Native Microfibrillated Cellulose" 2015).

After Amanda Maloney attended the nanocellulose workshop mentioned above, she shared information on the workshop with NEDCC staff, who then made a series of cast films for practice and testing. The slurries for these films were later used as the basis for testing with direct application methods of MFC. A paper of comparable thickness to the fan's facing paper was found, folded, and torn along the fold to imitate a break in the fan package. These papers were then each mounted to the 4-ply rag supports that would be used during fan repair. The slurries used for testing were as follows:

- 1:1 mixture of 2.6% Celova® nanogel: (1:4 ratio) wheat starch paste
- 2.6% Celova® Nanogel, undiluted
- 0.2% Celova® Nanogel slurry in filtered water
- 0.2% Celova® Nanogel slurry in filtered water with Winsor and Newton Lamp Black Gouache
- 0.2% Celova® Nanogel slurry in ethanol
- 0.2% Celova® Nanogel slurry in 1:1 ethanol: filtered water
- 0.2% Celova® Nanogel slurry in 1% methylcellulose
- 0.2% Celova® Nanogel slurry in 1:1 2% Klucel G:1% Klucel M in ethanol

Because the samples were just small sections of paper, they needed to be restricted to imitate the fan package and were held in place with low tack tape at the ends of each paper to shaped supports (fig. 4). A single layer of each solution was applied directly with a 00 sable brush to the breaks in the papers and were allowed to dry completely—a process that appeared to take approximately 3 hours for the 0.2% slurries

Fig. 4. Paper samples mounted to the fan supports during testing.

and 12 hours for the undiluted nanogel. As when casting the films, the samples could not be moved or adjusted during this time and had to remain where they were so as not to disrupt the nanocellulose.

The 0.2% Celova Nanogel slurries in ethanol and in 1:1 ethanol: filtered water did not join together at all, even after a secondary application. No further testing was done with these options after this point. All other samples appeared to repair the tear by pulling the paper back together and were moved to the stress testing phase. While the 0.2% Celova® Nanogel slurries in filtered water, 1% methyl cellulose, and 2% Klucel G:1% Klucel M appeared to be good options at first, they broke easily after they were manipulated several times as if they were part of a moving fan. To confirm the mechanical failure was not a result of insufficient drying time, samples were prepared a second time and allowed to dry overnight. The results were slightly improved, but these samples still broke after manipulation. Given that the failure required more manipulation of paper than would be considered "normal" handling for a flat paper object, there may be some potential in using these slurries as direct applications on targeted repair areas in other heritage materials.

The 1:1 mixture of 2.6% Celova Nanogel: wheat starch paste and undiluted 2.6% Celova Nanogel held up best both when applied and when manipulated like a fan. These samples took longer to fully dry in comparison to the others. However, as they were more visually noticeable when applied, it was also much easier to determine when they had fully dried as they became nearly invisible and decreased significantly in size. Given their visual thickness on application, a few other tests were conducted to determine what was the smallest amount that could be applied for a stable repair.

As a final test, a small sample of the two slurries were applied in an unobtrusive area on one of the fans. It was quickly noted that the undiluted 2.6% Celova® Nanogel was too wet and would cause minor tidelines if used for treatment. The slurry was removed with desiccated blotters and dried rapidly. The 1:1 mixture worked much better, as the addition of wheat starch paste assisted in decreasing the ratio of water in the gel enough to prevent any tidelines on the pieces. Through the initial tests, it was determined the 1:1 mixture would be most suitable for targeted applications of isolated failure points or in areas that cannot be easily accessed. In some ways, this perhaps makes the repair done in this treatment closer to a consolidation of the paper fibers rather than a mend via hydrogen bonding as described by Dreyfuss-Deseigne.

CASE STUDY: THREE GILBERT AND SULLIVAN FANS

The three fans in this case study are souvenir items from the early 1900s depicting scenes from Gilbert and Sullivan's *The Mikado*, *H.M.S. Pinafore*, and *Pirates of Penzance*. The fans were

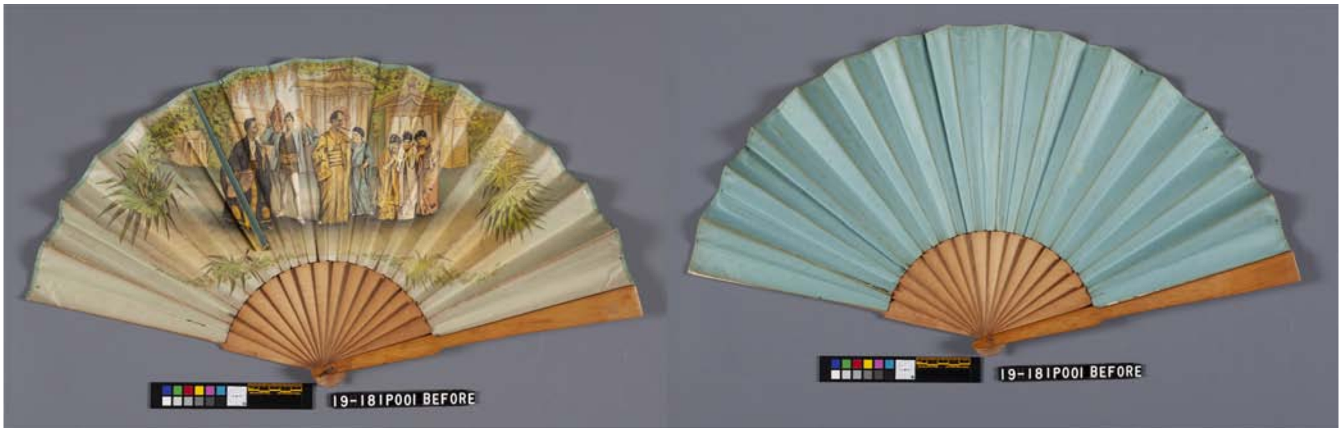

Fig. 5. *The Mikado*, before treatment.

printed using lithography or chromolithography with *Pinafore* having the addition of gold gilt surrounding the image. The *Pinafore* and *Pirates* fans had a black lacquer-like decorative paper as the verso paper on their fan package, while *The Mikado*'s was a blue toned wood pulp paper. The gilt and lacquer papers were approached with caution as they were unforgiving and would stain easily or become matte if too much water was applied with both MFC direct applications and traditional mends.

Although varying in degree, the fans all had similar types of damage. In the fan for *The Mikado* (fig. 5), there were multiple areas of weakened paper and minor loss near the guards, which is a point of high stress in the opening and closing of the fan. On the left half of the recto paper, the paper was split along the mountain fold through part of the image and torn perpendicular to this fold. Other tears were present along the peaks of the outermost leaves though they were not as obvious at first glance. The fan for *Pirates of Penzance* (fig. 6) had breaks that tore both of the fan papers. Additionally, it had one unfortunate tear and misalignment that was causing the sticks to function improperly just left of the center. Of the three fans, the *H.M.S. Pinafore* (fig. 7) was the most damaged with two complete breaks, numerous partial tears, abrasion to the gold gilt, and splitting of the mountain peaks on the fan package. In some ways, the extensive damage on *Penzance* and *Pinafore* would have made it easier to do some of the traditional repairs as the full breaks allowed for access to the interior of the fan leafs.

As mentioned earlier, supports for each fan matching the width and angle of the fan leaves needed to be made prior to beginning treatment. The head and tail of the fans were measured carefully so that 4-ply rag board could be cut, scored, and folded to match the folds of each fan. Wedges of Hollytex and blotter were also prepared to assist with drying repairs and preventing them from accidentally adhering to the supports. The 4-ply rag supports had long Delrin dowels inserted underneath. By pulling or pushing the dowels under the fan support, the height of each leaf could be controlled in a gentle manner to accommodate the slight lift of the fan package while also providing a firm support for the weight

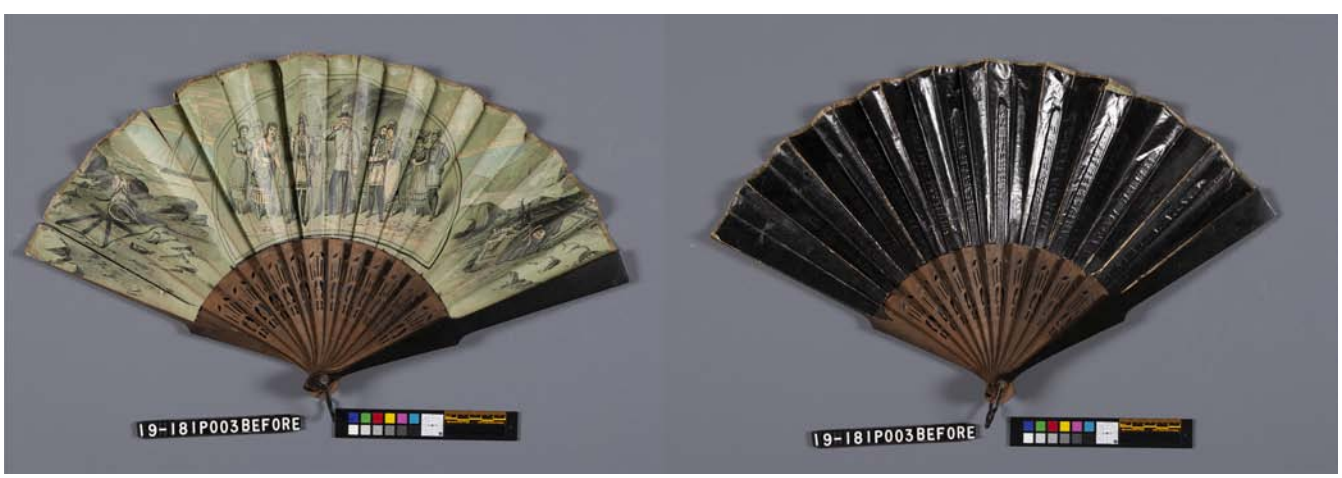

Fig. 6. *Pirates of Penzance*, before treatment.

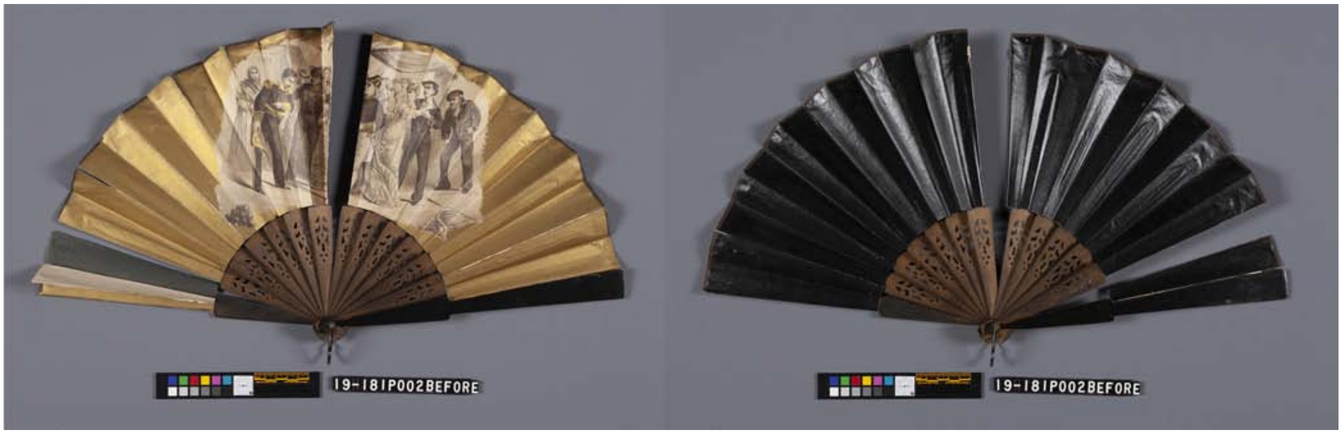

Fig. 7. *H.M.S. Pinafore*, before treatment.

that would go on top of the fan. While Delrin was used for this treatment, small diameter wooden dowels (5–8 mm) or other similar sticks would also be suitable for use.

Although significant durability and flexibility was observed during testing on the trial samples, there was still concern as to whether the direct application of MFC would stabilize the fans adequately in areas of severe breaks, as seen on the *Pinafore* fan. As these items are owned by a private client, it is safe to assume that they will be handled more regularly than if they were owned by an institution. As such, the areas of complete separation had the addition of a handmade Tengujo 9 gsm Japanese tissue paper repair applied in a traditional manner first.

On the *Pinafore* and *Pirates* fans, the repairs to the interior of the fan leaf were done in stages. The Japanese paper repairs were first attached along the length of the break with one tissue repair on opposite sides of the recto and verso papers and allowed to dry. Once dry, the fan was placed on the 4-ply rag supports and lined up to complete the repair by first connecting the two halves of the verso paper, allowing it to dry, and then repeating the process with the recto paper and the addition of a protective silicone film barrier support between the two sheets of paper. Once dry, the protective support was removed and the reconstruction of the fan package was complete with the exception of minor breaks (fig. 8).

On *Mikado*, where there were only partial or breaks only on the recto paper, the repair tissue was attached in one go by first tucking it under the rib side of the fan leaf, aided by an angled polyester strip, before the area was boned down to ensure a good attachment. The papers and polyester were then manipulated so they fit into the interior of the leaf between the recto and verso papers. As a final step, the two sides were then aligned as much as possible using the mat board support to recreate a gentle angle (fig. 9). These Japanese tissue mends were allowed to dry completely under local weight before approaching the repair and reinforcement with the nanocellulose and wheat starch paste mixture.

Fig. 8. Local isolated repairs on *H.M.S. Pinafore* with toned tissue.

As the Celova® Nanogel and wheat starch paste mixture dried out rather quickly, it was made in small batches for immediate use on each of the three fans as needed. This also provided the opportunity to control the amount of moisture

Fig. 9. Repair with Japanese tissue paper on *Mikado*.

Fig. 10. In progress repair with Celova® Nanogel: wheat starch paste mixture on *H.M.S. Pinafore.*

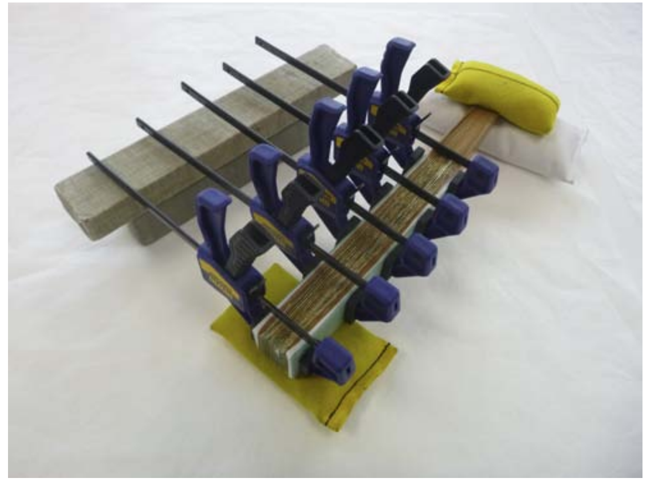

Fig. 11. Clamped fan post treatment.

more tightly if needed, as was the case when addressing the gilding on *Pinafore*. It was decided to use the mixture on areas that were weakened and would break in the future or those areas that were already broken but would be very difficult to access without extensive manipulation of the fan package and could result in damage. As such, rather than applying it along the entire length of the mountain or valley fold, it was only applied to areas that showed extensive fraying and appeared heavily worn (fig. 10). In some cases, the fan paper needed to be held in place for about 10 to 15 minutes to "set" the Celova Nanogel. In others, the paper had to be manipulated slightly for a better alignment of paper fibers. Neither manipulation of the fan paper was as extensive as what needed to be done for the traditional mends. After the initial application, the fan could not be moved or manipulated for at least 24 hours without causing some failure to the repair. Each repair was tested to ensure limited visual change in the surface as well as overall strength and ensure it was not causing further fracturing or paper splitting along the fold.

The final stage of treatment was to clamp the fans under pressure to fully introduce the folds to the repaired areas and re-familiarize the fans with how to open and close after they had been manipulated during treatment for so long (fig. 11).

CONCLUSION

The use of the nanogel mixture on the three fans allowed for decreased overall manipulation of the fan package to strengthen areas that were difficult to access or were showing signs of paper fraying. It created a strong invisible repair that did not inhibit the functionality of the fan when opened or closed. While solvents, watercolor, and synthetic adhesives were not added to the nanogel mixture used in this case study, Celova Nanogel blended well with these materials during initial tests and a combination of these materials with nano gels may be suitable for flat paper objects. Given that the undiluted 2.6% Celova Nanogel was only rejected for use in this case study due to being too wet for the fan paper, there is also a possibility that it may be used without further modification in other treatment scenarios for invisible repairs on par with techniques such as the fine fiber stitch methodology (fig. 12).

While nanogel was used successfully to consolidate areas of minor tears and fraying in this case study, its use should be considered carefully as it can be challenging and requires practice to apply appropriately. There is also significant downtime while the nanogel dries, which makes it unideal for objects that cannot remain out for long periods of time

Fig. 12. After treatment photos of the three fans.

or where opened items without adequate support can be strained. As with any treatment, conservators should weigh their options and utilize techniques that play off the strength of the materials to provide reinforcement and support of the objects in our care.

ACKNOWLEDGMENTS

Many thanks to Amanda Maloney for sharing the information that she learned at the Applications of Nanocellulose in Conservation Workshop 2018 at the Museum of Fine Arts, Boston when she was a member of staff at NEDCC. Thanks also to the client, Donald J. Smith, for allowing me to present on the project at the annual meeting and in the BPG Annual.

NOTE

1. At the 50th annual meeting it was mentioned to the author in passing that there were articles in French by Rémy Dreyfuss-Deseigne on using the direct application technique that was mentioned at the Nanocellulose workshop. While the author has not found these articles yet due to a lack of time, she believes it is important to include this note for those who may wish to find them or to reach out to Mr. Dreyfuss-Deseigne directly with more questions on the technique as she is not an expert on MFC.

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SOURCES FOR MATERIALS

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https://weidmannfibertechnology.com/

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MADISON BROCKMAN AND LAURA MACCARELLI

Pressing Politics: A Technical Study of German and Mexican Political Prints from the Los Angeles County Museum of Art

INTRODUCTION

In advance of the Los Angeles County Museum of Art (LACMA) exhibition titled *Pressing Politics*, co-curators Erin Maynes (Assistant Curator, Rifkind Center for German Expressionist Studies) and Rachel Kaplan (Assistant Curator, Latin American Art) organized a technical study of objects from each of their respective collections with LACMA Conservation, including Madison Brockman (Assistant Paper Conservator), Laura Maccarelli (Associate Conservation Scientist), and Yosi Pozeilov (Senior Imaging Specialist and Photographer). To the authors' knowledge, this is the first in-depth investigation at LACMA into the materials and techniques used to produce the paper supports and printing inks found in these collections. Understanding the raw materials and their processing is key to prolonging their lives through preventive conservation efforts.

Pressing Politics will showcase approximately 60 works of political graphic arts from LACMA's Rifkind Center for German Expressionist Studies and the Latin American Art department and will be installed in the fall of 2022 at LACMA's satellite gallery at Charles White Elementary School, an LAUSD Visual Arts Magnet. This exhibition will be LACMA's first that brings together these powerful images from Germany and Mexico to explore their shared subject matter and artistic strategies. The artworks juxtapose their respective cultures and periods of time, as the curators examine the motivations for creating such charged political imagery, the means of disseminating such images, and their impacts on the development of global modernism.

The study was carried out to investigate the materials and manufacture of a variety of prints, from fine art portfolio prints to mass-produced broadsides and books. The curators hypothesized that each collection may be partly comprised of poor quality, nontraditional, or otherwise unusual materials given that the objects were produced in geographic regions and historical periods characterized by economic hardship or scarcity of "traditional" fine art–making materials (from a Euro-centric perspective). For example, the study prints selected from the Rifkind collection of German Expressionist art were created in the waning years of World War I, a time of great economic hardship after Germany had been depleted of its resources for years. Similarly, study prints from the Latin American Art collection were largely created in the few decades after the Mexican Revolution and often emphasized mass production and consumption.

First impressions

The curators worked with Assistant Conservator Madison Brockman to select an array of paper types from each collection on the spectrum of "fine art collectibles" to "ephemera." This range included one-off fine art prints to collectible portfolios to images and text produced en masse for wide distribution. Eight are flat sheets and two are books; all except one of the ten objects are printed exclusively in black ink. The images all have a social, economic, or political message, as they are all either part of or similar to objects selected for the *Pressing Politic*s exhibition.

Paper characteristics

The paper supports from the study sample ranged from what appeared to be white cotton rag paper to cream-colored papers of unknown fiber content to those that were quite obviously aged wood pulp papers, given their brittleness and heavy yellow/brown discoloration. Some had somewhat textured to fairly lively surface characteristics with irregular fiber deposition; others were highly uniform and calendered, with little to no surface character. For this study, the sizing was not examined. For those papers on each end of the spectrum, their initial fiber and manufacturing method identifications were essentially borne out in the end, while analysis of the unknown papers in the middle proved to be quite fascinating.

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

METHODOLOGY

Visual/microscopic examination

All 10 objects in the sample selection were first examined with both the unaided eye and a Leica WILD M32Z microscope with a Techni-Quip Corp. T-Q/FOI-1 150w fiber optic illuminator. This provided information about the materials and manufacture, for example, determining the printing process and whether the support was hand- or machine-made. The supports were visually and microscopically assessed in normal and raking light to subjectively characterize their color, thickness, and surface texture based on the categories established by the Print Council of America (Lunning 1996). Also noted were any relevant condition issues, printing or papermaking irregularities, the degree of processing, and other unique qualities of the sheet. A Keyance VHS 2000 digital microscope was used for further microscopic examination of the papers' surfaces. This microscope was selected for its 200x magnification and image-capture capabilities.

XRF

X-ray fluorescence (XRF) analysis was performed on all study sample objects. XRF is a nondestructive technique that detects different elements present by directing x-rays at an object and measuring the unique fluorescent x-rays that bounce back. It was used to identify any elements present in the object relating to inorganic paper fillers, ink, pigments, or impurities. The instrument used was an Olympus Delta InnovX in Geochem mode.

MFT

Micro-fade testing (MFT) was undertaken to evaluate the light sensitivity of the objects. The micro-fade tests were carried out with a Tru-Vue Conservation Clear Acrylic filter in the light path to determine the sensitivities of these areas under typical museum lighting conditions—i.e., light with spectral outputs that do not include ultraviolet radiation. The MFT curves obtained from the different areas of the object were compared to those of ISO Blue Wool Standards (CAMEO 2020). The light sensitivity was then determined according to the definitions in table 1 (Michalski 2018).

Fiber identification

The fiber(s) in each paper support were identified by examining a very small sample with a polarizing light microscope. Only a few fibers are necessary for an effective sample size, and after their removal the sampling location is not noticeable to the unaided eye. In general, fibers were extracted from the supports in the bottom left corner of the verso, with some exceptions: the two books were sampled in the bottom left corner of the (left) page opposite the image, and objects with tears or losses where fibers were already disrupted were sampled in those areas. Under the stereomicroscope, a very small droplet of filtered water was placed on the surface, allowing the fibers to swell locally. Very fine tweezers were used to remove a few fibers from the surface of the support, which were placed on a glass microscope slide. The sampling area was gently burnished down and dried flat. The fibers on the slide were covered with a glass coverslip, and water was fed in between prior to microscopic examination. A Nikon Microphot with a Leica DMC 4500 camera was used in transmission mode, with LasX software used to capture images of the magnified fibers. For further confirmation of fiber type and processing method, Graff's "C Stain" was used to stain the same samples for each object. This microchemical spot test provides information on the lignin content of the fibers by reacting to produce different colors.

Light Sensitivity	Fading Rate Without UV	Recommended Exhibition Light Levels
Extremely light sensitive	Faster than BW1	3–5 ftc (30–50 lux)
Very light sensitive	Between BW1 & BW2	5 ftc (50 lux)
Moderately Sensitive	Between BW2 and BW3	5 ftc (50 lux)
Somewhat Sensitive	Between BW3 and BW5	5–10 ftc (50–100 lux)

Table 1. Light sensitivity categories for works of art

RESULTS

The results from XRF, MFT, and fiber identification are listed in tables 2–7.

Object Number	Artist, Title, Date	Elements Detected
M.2003.92.39	Arturo García Bustos, *Campesinos mixes* (ca. 1940)	Ca only in paper areas. Ca, S, and Fe in ink areas
M.2003.92.58	Leopoldo Méndez, *La protesta* (1943)	Si, S, K, Ca, and trace amounts of Fe and Ni in both paper and ink areas
M.2003.92.71	Taller de Gráfica Popular, *Maestro tú estás solo contra …* (1940)	Si, S, Ca, and trace amounts of Ni in both paper and ink areas
M.2003.92.131	Alberto Beltrán, *Lázaro Cárdenas y la guerra de España* (1947)	Si, S, Ca, and trace amounts of Ni in both paper and ink areas
AC1994.156.11	Alfredo Zalce, *Lumber Workers* (1946)	Si, S, Ca, and trace amounts of Ni in both paper and ink areas

Table 2. Elements detected by XRF in the TGP objects

Object Number	Artist, Title, Date	Elements Detected
M.82.288.73f	George Grosz, *The World Made Safe for Democracy* (1919)	Ca only in paper areas. Trace amounts of Fe in ink areas
83.1.28a	Wilhelm Plünnecke, *Untitled (Die Marseillaise)* (1919)	S and Ca in paper areas. S, Ca, and trace amounts of Fe in ink areas
M.82.288.270	Karl Schmidt-Rottluff, *Christus* (1918)	Si, Ca, and Ti in paper areas. High amount of Fe in ink areas
83.1.1	Max Pechstein, et al., *To All Artists! (An alle Künstler!)* (1919)	S, Si, K, Ca, Fe, and Ni in both paper and ink areas
83.1.140f	Conrad Felixmüller, *Dead Comrade* (1919)	S, Si, Ca, and Fe in both paper and ink areas

Table 3. Elements detected by XRF in the Rifkind objects

Object Number	Artist, Title, Date	Blue Wool Standard
M.2003.92.39	Arturo García Bustos, *Campesinos mixes* (ca. 1940)	Paper: BW2-3, moderately light sensitive (100000fc.hrs). Ink: <BW3 somewhat light sensitive.
M.2003.92.58	Leopoldo Méndez, *La protesta* (1943)	Paper: BW2-3, moderately light sensitive (100000fc.hrs). Ink: <BW3 somewhat light sensitive.
M.2003.92.71	Taller de Gráfica Popular, *Maestro tú estás solo contra …* (1940)	Paper: BW2-1, very light sensitive (30000fc.hrs). Ink: BW2-3, moderately light sensitive (100000ftc.hrs)
M.2003.92.131	Alberto Beltrán, *Lázaro Cárdenas y la guerra de España* (1947)	Paper: BW2-1, very light sensitive (30000fc.hrs). Ink: <BW3 somewhat light sensitive
AC1994.156.11	Alfredo Zalce, *Lumber Workers* (1946)	Paper: BW2-1, very light sensitive (30000fc.hrs). Ink: <BW3 somewhat light sensitive

Table 4. MFT results from the TGP objects

Object Number	Artist, Title, Date	Blue Wool Standard
M.82.288.73f	George Grosz, *The World Made Safe for Democracy* (1919)	Paper: BW2-3, moderately light sensitive (100000fc.hrs). Ink: <BW3 somewhat light sensitive.
83.1.28a	Wilhelm Plünnecke, *Untitled (Die Marseillaise)* (1919)	Paper: BW2-1, very light sensitive (30000fc.hrs). Ink: <BW3 somewhat light sensitive
M.82.288.270	Karl Schmidt-Rottluff, *Christus* (1918)	Paper: BW2-1, very light sensitive (30000fc.hrs). Ink: <BW3 somewhat light sensitive
83.1.1	Max Pechstein, et al., *To All Artists! (An alle Künstler!)* (1919)	Paper: BW2-3, moderately light sensitive (100000fc.hrs). Ink: <BW3 somewhat light sensitive.
83.1.140f	Conrad Felixmüller, Dead Comrade (1919)	Paper: BW2-3, moderately light sensitive (100000fc.hrs). Ink: <BW3 somewhat light sensitive.

Table 5. MFT results from the Rifkind objects

Object Number	Artist, Title, Date	Fiber Composition	Observations
M.2003.92.39	Arturo García Bustos, *Campesinos mixes* (ca. 1940)	Cotton	C Stain: bright red, indicating high alpha-cellulose content
M.2003.92.58	Leopoldo Méndez, *La protesta* (1943)	Bleached/processed hardwood fiber (?)	Big chunks of fiber, not well separated into fibrils. C stain: all deep indigo blue thin fibers
M.2003.92.71	Taller de Gráfica Popular, *Maestro tú estás solo contra …* (1940)	Bleached wood	C stain: blue, indicating purified pulp
M.2003.92.131	Alberto Beltrán, *Lázaro Cárdenas y la guerra de España* (1947)	Bleached wood	C stain: mostly red, small amount of blue, indicating mostly bleached wood and some purified pulp
AC1994.156.11	Alfredo Zalce, *Lumber Workers* (1946)	Bleached wood	C stain: mostly bluish, indicating somewhat well processed pulp

Table 6. Fibers present in the TGP objects

Object Number	Artist, Title, Date	Fiber Composition	Observations
M.82.288.73f	George Grosz, *The World Made Safe for Democracy* (1919)	Cotton, some partially processed wood	C stain: lots of red, some blue-to-yellow, indicating mostly alpha-cellulose with some partly processed pulp
83.1.28a	Wilhelm Plünnecke, *Untitled (Die Marseillaise)* (1919)	Unbleached, mechanical wood	C stain: all yellow, indicating high lignin content
M.82.288.270	Karl Schmidt-Rottluff, *Christus* (1918)	Bleached hardwood and wool, some unbleached wood	C stain: mostly blue, some yellow, indicating mostly purified pulp
83.1.1	Max Pechstein, et al., *To All Artists! (An alle Künstler!)* (1919)	Bleached wood	C stain: dark blue, indicating well-processed pulp
83.1.140f	Conrad Felixmüller, *Dead Comrade* (1919)	Bleached wood	C stain: dark blue, indicating well processed pulp

Table 7. Fibers present in the Rifkind objects

DISCUSSION

Materials: paper

When assessing this group of 10 objects as a whole, the most striking result of analysis is that there is much more wood pulp present than initially hypothesized. Unknown papers were presumed to be possibly cotton and wood pulp blends, with some inorganic fillers or bleaching treatments. That many of these objects are composed solely of bleached wood pulp is remarkable—especially given that many of them were used to create "fine art" or collectible prints, not ephemeral ones.

Most of the wood used as paper pulp is softwood, which is abundant and easier to process than hardwood. Some objects do appear to contain vessels, including Leopoldo Méndez's *La protesta* and Karl Schmidt-Rottluff's *Christus*. Softwood is composed of fibers (tracheid cells) and ray cells exclusively, whereas hardwoods are more complicated biological structures that also contain large vessels, their hallmark.

The presence of sulfur in these wood pulp papers indicates sulfite or sulfate (kraft) processing; it is unclear which process was used for each object. XRF analysis does not always detect "lighter" elements like sulfur unless there is a large enough amount of it to do so; the fact that sulfur was detected in all of the papers identified as wood pulp indicates that it likely comes (in large part) from processing and is not just an impurity or part of the chemical composition of an inorganic filler.

While most of the wood pulp papers contain fibers processed with a sulfur-based method, some are only partially processed and still contain high levels of lignin. This may contribute to increased acidity, discoloration, and brittleness of the support over time. One object, Wilhelm Plünnecke's *Untitled (Die Marseillaise)*, contains only mechanically processed wood with a very high amount of lignin; this likely explains why the sheet is brittle and dark brown in color.

Some objects do indeed have blends of pulps, including wood, cotton, and others. One object, Karl Schmidt-Rottluff's *Christus*, has a large amount of wool fibers in the paper matrix (fig. 1). Wool (and other proteinaceous animal fibers) are not common in papers, especially modern papers from the 20th century, and may indicate that papermaking resources were scarce enough to warrant recycling textiles, which included wool fibers.

Materials: inorganic fillers

Many of these papers also appear to contain inorganic fillers, and while the analytical techniques used in this study cannot identify specific minerals or pigments, deductions can be made based on the elements present. Fillers are added to use less pulp and bulk out the sheet, to increase water repellency or the opacity of the sheet, and to buffer the sheet against future acidity, among other reasons. Calcium is common to papers, as divalent calcium ions help cross-link cellulose polymer chains and make the sheet strong. However, calcium can also be found in calcium carbonate (chalk) and calcium sulfate (gypsum), common white pigments and fillers.

Seven out of the 10 sample objects contain silicon, an indication that a clay component was added to the paper, either as

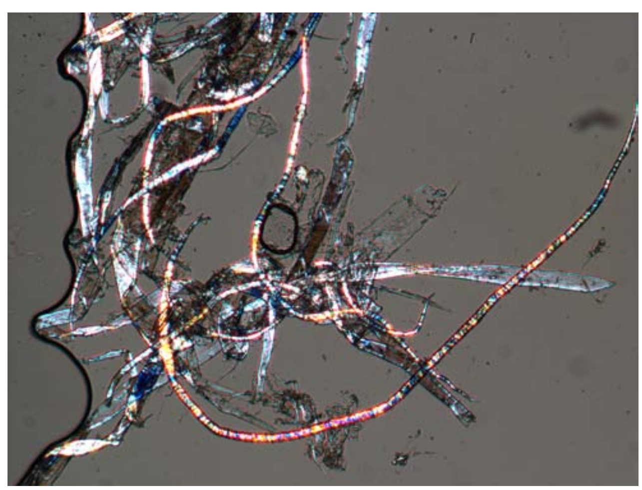

Fig. 1. Polarized light microscope image of Karl Schmidt-Rottluff's *Christus* (1918) with wool fibers visible, 10x magnification. Photo © Museum Associates/LACMA Conservation, by Madison Brockman.

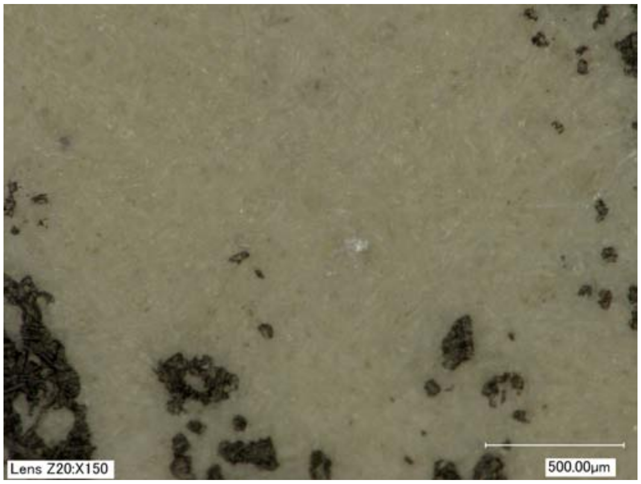

Fig. 2. Digital microscope image of Conrad Felixmüller's *Dead Comrade* (1919) showing a large, shiny, inorganic filler particle on the surface. Photo © Museum Associates/LACMA Conservation, by Laura Maccarelli.

a filler or surface treatment. Silicon is also not always detected by XRF analysis unless the concentration is high enough to be picked up by the instrument, which would be the case if a large amount of clay or silicate mineral is present, like talc (Mg3Si4O10(OH)2). Potassium, iron, and titanium can all be found in various types of micas. Titanium white was not commercially produced in Europe until 1923 (CAMEO 2020), so the titanium present in Karl Schmidt-Rottluff's *Christus* is likely bound up in a natural mineral source given that the artwork was made in 1919.

Some of these objects have such large amounts of inorganic fillers that the surfaces appear to be smooth and characterized by shiny particles embedded in the support, as seen on the surface of *Dead Comrade* (fig. 2). MFT analysis of these objects loaded with inorganic fillers showed that the papers were less light sensitive than other wood pulp papers, on par with the cotton rag papers, likely because there is simply not as much light-sensitive wood pulp in relation to the inorganic fillers that make up the sheets.

The source of the trace amount of nickel in many of these objects is unknown; nickel most commonly relates to art materials in terms of green inks and colorants (Elmas 2018), though that is not relevant to these objects.

Materials: ink

For the most part, the black printing inks in this study sample can safely be characterized as containing carbon-based black pigments. Carbon is too light to be detected by XRF; any other elements detected in qualitatively larger concentrations are likely from the paper substrate beneath the ink.

There may be trace amounts of iron especially as impurities either from naturally forming earth pigments or from manufacturing equipment that may contain iron, though this is less likely in the modern era of pigment and ink manufacture. One alternative explanation to the qualitatively greater presence of iron in the inks is that iron could have been used as a drying agent to accelerate the cross-linking of the oil binder. Cobalt is a more common oil drying additive for fine art materials (printing ink and oil paints), but iron is used in more commercial or industrial products like tung oil.

For *Christus*, the amount of iron present is too great to be an impurity or oil-drying agent; it is most likely that this ink was made with Mars black, an iron-containing black pigment (CAMEO 2020).

For *Lumber Workers*, XRF analysis detected chromium in the red ink, which could indicate the use of chrome red pigment (CAMEO 2020), though no lead was detected. This could be the case if the amount of lead in the pigment itself or in the ink was too small to be detected, as lead is a heavy metal and is usually identified by XRF analysis. Otherwise, the chromium could indicate the presence of another chrome-containing red that does not also contain lead. XRF analysis did not indicate the presence of any pigment-associated elements in the green ink, which may indicate that the ink was made with an organic pigment or dye as the green colorant.

Manufacture

Most supports appear by their even fiber dispersion and smooth surfaces to be machine-made, which goes hand-in-hand with the use of processed wood pulp, and only two appear to be handmade. Leopoldo Méndez's *La protesta* is quite obviously handmade as seen by its irregular fiber deposition and deckle edge (fig. 3), though its processed woody fiber content is an unusual selection for handmade paper. It may be possible that this is another woody plant or grass that was processed like traditional wood pulp, though its exact identity is not confirmed at this time. The other paper that appears to be handmade is George Grosz's *The World Made Safe for Democracy*, printed on a laid paper with a "Drey Könige" watermark and "G. F." countermark visible in transmitted light. For the remainder of the objects, being machine-made is not at all out of the ordinary given that by the 20th century this was the most common means of production for all papermaking, from art papers to commercial papers. For example, Arturo García Bustos' fine art print *Campesinos mixe*s is printed on Arches paper, for which there is reliable manufacturer's information indicating that this is a machine-made paper.

Preventive recommendations

Based on MFT analysis and fiber identification, the inks are likely to remain stable while the supports will likely darken and become brittle over time. This is especially the case with wood pulp papers. For those wood pulp papers that are already highly discolored and embrittled, like *Christus*, the change may not be so drastic going forward as much of it has already occurred. For other objects that contain processed wood pulp, more color change may occur with significant

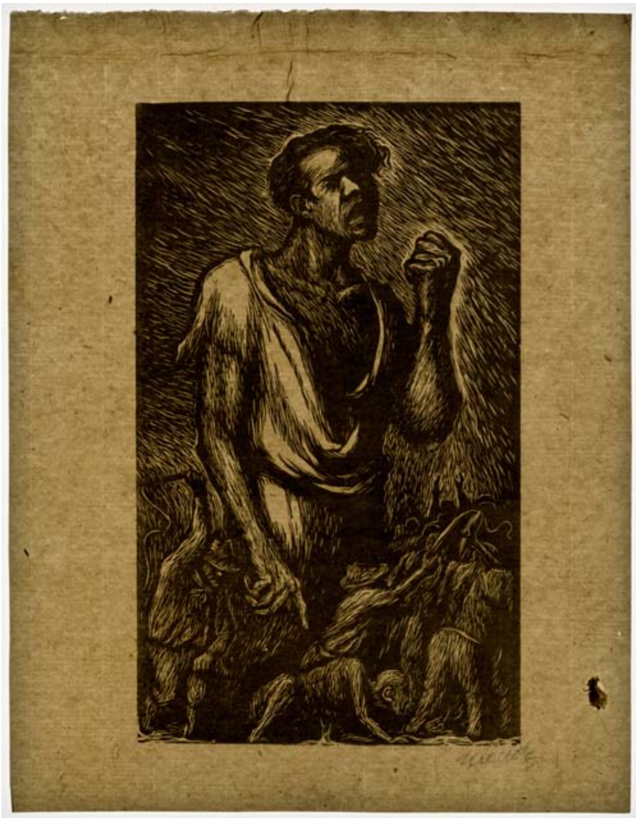

Fig. 3. Transmitted light image of Leopoldo Méndez's *La Protesta* (1943), with deckle edge, unprocessed fiber clumps, and irregular fiber deposition. Photo © Museum Associates/LACMA Conservation, by Yosi Pozeilov.

light exposure in the future. For exhibition light limits, 5 footcandles are suggested with UV filtration. Although these objects will not require relative humidity parameters out of the norm, they should not be kept in a dry environment given their brittleness and should be stored and displayed around 50%–55% RH.

CONCLUSION

This study revealed the materials and manufacturing techniques used to produce previously unidentified papers and unearthed some surprising new information about what materials were either consciously or unconsciously chosen by artists and printers. The use of "nontraditional" commercial, industrial, or recycled materials may indicate an art material shortage or may simply demonstrate a 20th-century shift away from papers previously used in printmaking. Whether this shift was driven by economics or social pressures will be left to the curators to interpret, but simply knowing that these initial hypotheses were largely confirmed changes how these objects are viewed from pure speculation to more substantiated claims.

Armed with the knowledge of these paper supports' composition, paper conservators, curators, and others involved in the care and display of these fragile artworks are better equipped to understand how the objects may change in the future. Further damage can be mitigated through preventive conservation efforts like reducing light levels and exhibition duration, ensuring storage and display materials are acid- and lignin-free, and managing the environment to avoid extreme or fluctuating temperature and relative humidity levels. While these efforts are made to protect all of the works on paper in LACMA's collections, they protect the most vulnerable works—like the prints in this study—most effectively, preventing damage at the molecular level, which often cannot be undone by even the most skilled conservator.

ACKNOWLEDGMENTS

My immense gratitude to Erin Maynes and Rachel Kaplan for initiating this project, for their expertise, and for their collaboration for well over a year. I would like to thank Yosi Pozeilov for his superb documentary imaging of each object in normal, raking, transmitted, and UV light. Many thanks also go to the Mellon Foundation for providing funds for the Fellowship in Paper Conservation I held for the majority of this research project. And finally, I am grateful for the knowledge and support of Janice Schopfer and Soko Furuhata from the LACMA Paper Conservation lab.

APPENDIX 1. VISUAL/MICROSCOPIC EXAMINATION

TGP Objects

1. **M.2003.92.39**

Arturo García Bustos, *Campesinos mixes* (ca. 1940)

Media: linocut – black printing ink on machine-made Arches wove paper

PCA descriptions: cream (3), moderately thick to thick, slightly textured (2)

Observations: The support is a standard fine art printmaking paper from Arches; it is thick, soft, and pliable; has what appears to be a deckle edge; and was made on a wove screen. No shive or inclusions are visible. Based on manufacturer's information, the support is made on a cylinder mold and is likely cotton rag, not sized or only lightly sized for printmaking. The recto is less textured than verso.

2. **M.2003.92.58**

Leopoldo Méndez, *La protesta* (1943)

Media: Woodcut – black printing ink on handmade laid paper

PCA descriptions: cream (3), medium (1) thickness, slightly textured (2)

Observations: The support has an irregular texture on the recto, almost like brushy streaks, which did not come from the papermaking mould. The verso appears to have a more regularly textured surface from the mould screen. There are lots of unprocessed fiber inclusions and shive visible on the support surface and in transmitted light.

3. **M.2003.92.71**
Taller de Gráfica Popular (no artist), *Maestro tú estás solo contra …* (1940)
Media: Lithograph text and linocut image – black printing ink on orange-pink machine-made calendared wove paper
PCA descriptions: orange-pink (no PCA designation), between thin (2) and medium (1) thickness, very smooth texture

Observations: The image is printed on very thin, almost transparent paper that is dyed a peachy-orange color. It has a highly regular fiber deposition on a wove mould screen and is calendered or shiny on the recto and more rough or matte on the verso. There are some small inclusions and shive visible, but not a significant amount present.

4. **M.2003.92.131**
Alberto Beltrán, *Lázaro Cárdenas y la guerra de España* (1947)
Media: linocut – black printing ink on machine-made wove newsprint
PCA descriptions: beige (1), medium (2) thickness, smooth texture

Observations: The support is very flat and has a smooth, regular surface, characteristic of machine-made newsprint. A wove mould screen is visible in transmitted light. There is some shive visible, which is typically very small pieces. The support is fairly brittle and has a rattling sound when manipulated.

5. **AC1994.156.11**
Alfredo Zalce, *Lumber Workers* (1946)
Media: lithograph; black, orange-red, and green printing inks on machine-made wove paper
PCA descriptions: beige (1), between moderately thick and thick, moderately textured (2)

Observations: The support is heavily discolored (yellowed). There is a very small amount of inclusions or shive, though it is mostly a uniform paper without much variation in surface character. The support is almost certainly machine-made given its regular fiber deposition and flat surface character and is likely made from poor quality pulp due to its heavy discoloration. There is some latent foxing on the verso.

Rifkind Objects
6. **M.82.288.73f**
George Grosz, *The World Made Safe for Democracy* (1919)
Media: photolithograph – black printing ink on handmade laid paper ("Drey Könige" watermark and G. F. countermark visible in transmitted light)
PCA descriptions: cream (1), between medium (1) and (2) thickness, moderately textured (2)

Observations: This support is a handmade laid sheet with a deckle edge. It has a nice light color, a small amount of small shive fragments visible, and some colored fiber inclusions. It is moderately textured, soft and flexible, and is somewhat thin and translucent.

7. **83.1.28a**
Wilhelm Plünnecke, *Untitled (Die Marseillaise)* (1919)
Media: lithograph – black printing ink on machine-made thick wove wood pulp paper
PCA descriptions: between beige (2) and brown (no PCA color match), moderately thick, slightly textured (2)

Observations: The support appears very discolored, weak, and brittle; this is typical of an acidic, degraded wood pulp paper. There are many unprocessed wood shive and inclusions visible. The support has a very flat surface without a great deal of topographical character, typical for newsprint and many machine-made papers.

8. **M.82.288.270**
Karl Schmidt-Rottluff, *Christus* (1918)
Media: woodcut – black printing ink on machine-made wove paper
PCA descriptions: cream (3), between medium (2) and moderately thick, slightly textured (2)

Observations: The support seems fairly soft and weak due to its very short fibers. There is numerous very small light brown wood shive visible; the support also has tiny sparkly particles visible on the surface which are likely some sort of inorganic filler.

9. **83.1.1**
Max Pechstein, Cesar Klein, Hans Richter, Lyonel Feininger, Steger and Georg Tappert, *To All Artists! (An alle Künstler!)* (1919)
Media: lithograph (woodcut reproduction) – black printing ink on machine-made clay-coated wove paper
PCA descriptions: cream (3), medium (1) thickness, very smooth texture

Observations: The support is clay-coated and appears very brittle due to the short fibered wood pulp interior. The presence of inorganic fillers is also likely. The surface is very slick and smooth and has lots of unprocessed shive and flecks of shiny particles embedded further in the paper as well.

10. **83.1.140f**
Conrad Felixmüller, *Dead Comrade (in Das Kestnerbuch, after page 52)* (1919)

Media: lithograph – black printing ink on machine-made wove paper

PCA descriptions: beige (1), medium (2) thickness, smooth texture

Observations: The support seems fairly soft and weak due to its very short fibers. There is numerous very small light brown wood shive visible; the support also has tiny sparkly particles that are likely some sort of inorganic filler.

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Pamela W. Darling: Library and Archives Conservation Education and the Path to Columbia University[1]

On the morning of August 31, 1981, Columbia University's School of Library Service (SLS) gathered in Butler Library's Harkness Theatre for its annual new student orientation. Associate professor Paul N. Banks (fig. 1), director of the newly established Conservation Education Programs (CEP), sat with his faculty colleagues. Three graduate students specializing in Library and Archives Conservation and seven in the Administration of Preservation Programs in Libraries and Archives sat in the audience. After the long struggle to attain this moment, Banks relished the culmination of a long-cherished dream.

Indeed Banks had been a chief actor actively working towards formalized education for library and archives conservators since the 1960s. As the 1970s progressed, the ground for realizing a formal education program became increasingly fertile. Broadly signaling the growth of conservation interests in the US, the early 1970s saw the establishment of the AIC and the National Conservation Advisory Council, promulgating collaborations and standards with the authority of high-level sanctioning bodies. With regard to research libraries, the rapid growth of the educational and cultural sectors during the Cold War years resulted in a vast research library infrastructure that required ongoing care and tending to thrive. The range of initiatives aimed at library and archives collections preservation in the US multiplied at national, regional, and consortial levels. In 1973, the six state libraries in New England cooperated to create a shared conservation facility, originally named the New England Document Conservation Center (NEDCC), to meet the paper and parchment conservation needs of all nonprofit groups in New England.[2] By 1976, nine accredited library schools offered a course on the topic of preservation. According to one estimate, during the 1970s organizations such as the NEDCC, library schools, libraries, professional associations, and the like offered roughly 100 symposia addressing preservation subjects (Darling and Ogden 1981, 19). Federal funding for preservation initiatives in research libraries also took root in the mid-1970s via the National Endowment for the Humanities (NEH) (Darling and Ogden 1981, 21).

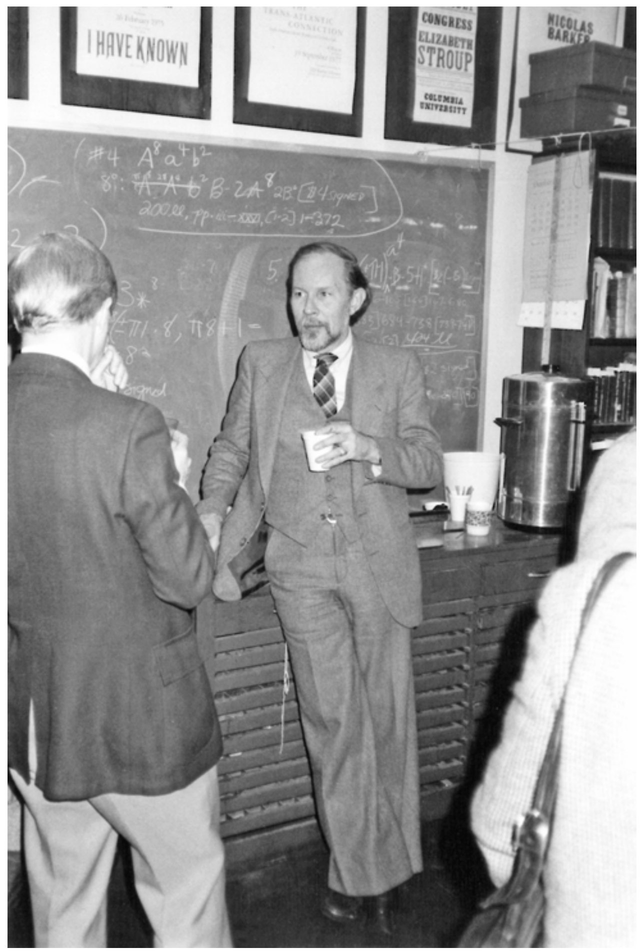

Fig. 1. Paul N. Banks in the School of Library Service Pressroom, 1981. Courtesy of Rare Book School, University of Virginia.

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

Fig. 2. Pamela W. Darling, ca. 1970. Courtesy of Pamela W. Darling.

While Paul Banks rightly deserves credit for his visionary drive to establish for the library and archives field some form of formal education—and certainly the program at Columbia would not have been possible without his enormous drive, commitment, vision, and deep knowledge—he did not get to Columbia alone.

PAMELA W. DARLING

Pamela W. Darling (fig. 2) has been a somewhat hidden figure in the Columbia story. By all evidence, it is unlikely that the Conservation Education Programs would have been established at Columbia without her influence, her adeptness and ease in partnering with Banks, and her vision for educating and building the nascent field. If her role was critical, why is she and her work to establish the field of conservation relatively unknown? Clearly, one reason is that historical accounts so often give due to the most visible and vocal actors—in this case, Banks. Moreover, it is no surprise that men have been much more thoroughly documented because they have routinely assumed high leadership positions, from which women were historically excluded. In recent decades, however, a massive corrective to the historical record has ensued, with increased focus on what is commonly referred to "secondary figures," "historically underrepresented groups," and "hidden women," and to the hidden collections and records that have not been privileged in the telling of predominant, hegemonic narratives.

There are other reasons conservators may not know about Darling's role in the early years of this field. One is that her career in library and archives preservation was relatively brief—from 1973 to 1986. She left the field to pursue a doctorate of theology, and her record in our field ended—now almost 40 years ago. Clearly, however, her significant role in the Columbia story is widely unknown because the records documenting her involvement are difficult to access. Columbia's SLS records comprise 395 linear feet and span approximately 70 years. When the author contacted Columbia a decade ago, the records the author requested were largely unprocessed, located in an offsite storage facility. The contents of the records storage containers in which the documents were housed reflected the original state and order of the records as they emerged from office file cabinets. While the evidence of Darling's influence in the Columbia CEP story was scant in corpus, it was revealing. It was from those traces of records that a fuller story began to emerge.

The Research Libraries Group (RLG) is key to understanding Darling as an actor in the early preservation administration milieu. In 1974, four of the nation's largest research libraries (New York Public Library and Harvard, Yale, and Columbia universities), officially formed the RLG, which officially incorporated in 1975. In the effort to connect the nation's library catalogs online, the RLG directors' primary concern was that the Ohio College Library Center (OCLC), formed in 1967, focused too predominantly on relatively homogenous English-language college collections. The directors wanted to form their own bibliographic network, which they eventually did, naming it the Research Libraries Information Network (Rogers 1988, 42). However, these libraries also held some of the oldest collections in the nation, including substantial numbers of rare, special, and archival collections. The directors were well aware of deteriorating paper in their book stacks. While many newer research libraries had air conditioning, none of the RLG libraries did. The metropolitan and/or industrial locations of the libraries left their collections subject to high levels of ambient pollution, combined with temperature and humidity conditions that varied substantially season to season.

The RLG's mission encompassed broad consortial interests, and it viewed preservation as key to the consortium's ability to provide services to scholars into the future. Perhaps somewhat unwittingly, the RLG directors made a key move to professionalize a broadly defined preservation field. In a sense, they enacted an informal consortial training program by appointing card-carrying librarians to newly created line positions—preservation administrators—charged with determining what kinds of organizational structures, systems, and funding would be required to preserve their collections. While these librarians knew little about preservation at the outset, singly and collectively they built their knowledge and set out to create multifaceted preservation operations. Moreover, the status of their respective institutions and the sanction of the RLG consortium provided them the voice of authority needed to lead the nation's research libraries into a better informed, organized, and comprehensive preservation dimension. They had clout in the research library world and, unlike conservators like Banks, they held the recognized certification of a graduate degree in library science. Through their work for RLG, their respective institutions, and in particular through the American Library Association, the new preservation managers promulgated best practices and policies for preserving research library collections. It is within this inventive and highly knowledge-needy consortium that Pamela Darling became a strong voice for educating preservation professionals.

Who was Pamela Darling? Born in 1943, Darling received her B.A. in English from Northwestern University in 1965 and soon after entered the Order of St. Helena. There she served as a novice before undertaking graduate studies in the School of Library of Service at Columbia University in 1969, receiving her MLS in 1971. After graduating, she completed a lengthy postgraduate internship at the Library of Congress. By 1973 she was heading back to New York City to marry Richard L. Darling (fig. 3), who served as dean of the School of Library Service from 1970 to 1984, and whom she met when she was a student. In June 1973 the New York Public Library (NYPL) hired Pamela Darling as Head of the Preservation Program Office. She worked alongside John Baker, who had been recently appointed Chief of the Conservation Division of the Research Libraries (Cooke 1989, 6). A year later in 1974, Columbia University Libraries, under Warren J. Haas's leadership, hired Pamela Darling as the libraries' inaugural Head of Preservation.

Darling's pursuit of education for the new field began at NYPL. Just four months into her tenure, she introduced her husband to the idea of incorporating conservation in the SLS curriculum. Drafting a memorandum headed "For the Record" and including Dean Darling as a recipient, she wrote that Terry Belanger (fig. 4), a new hire in the SLS eager to build a program in rare book librarianship, had met with her on September 17 to "explore the possibilities between NYPL and Columbia for setting up a program for training in conservation." They discussed the desirability of having an introductory course in conservation that covered both administrative and technical topics, but they had even larger ambitions: "Building on this, there might then be additional courses or workshops with a more technical orientation, in binding, repair and restoration, photoreproduction … and so on" (Darling 1973).

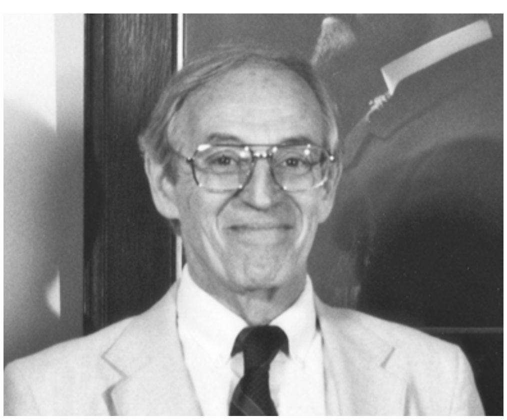

Fig. 3. Richard L. Darling, 1987. Courtesy of the Rare Book & Manuscript Library, Columbia University in the City of New York.

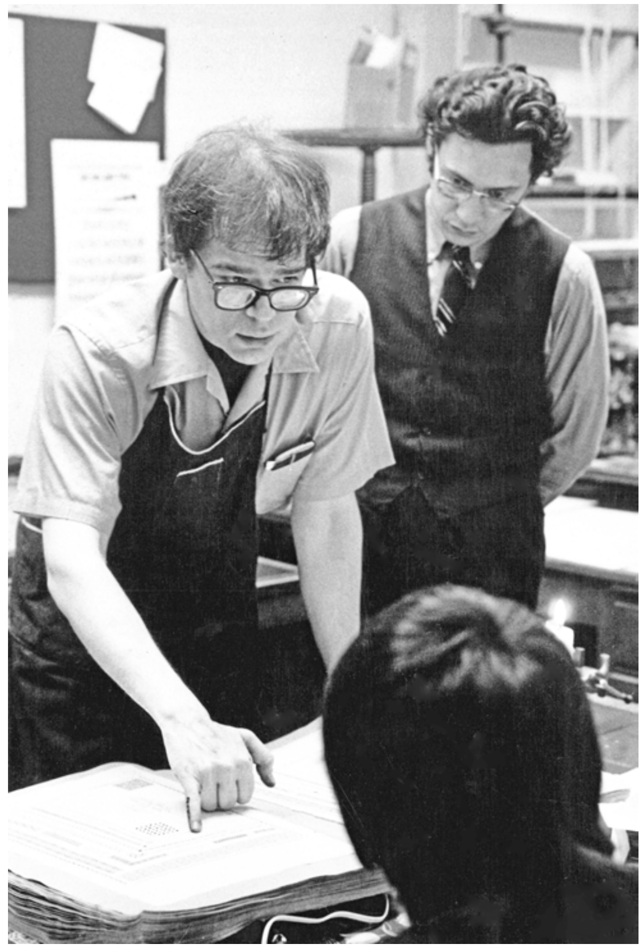

Fig. 4. Terry Belanger (left), ca. 1974. Courtesy of Rare Book School, University of Virginia.

Pamela Darling's ideas about educating a new field were stirred by an immediate and long-term need for conservators who possessed interdisciplinary knowledge and high-level skills—and for administrators who could build and manage comprehensive programs. The RLG institutions felt these needs all too urgently. While NYPL established a small conservation lab in 1970, it was not staffed to any extent. This was not unusual; just that year, Yale, which had no lab, hired Jane Greenfield as its first staff conservator. As of 1975, only two of the four RLG institutions (NYPL and Columbia) had relatively broadly scoped organizational units responsible for the development and implementation of preservation programs (Research Libraries Group 1975).

Banks and Darling did not know each other in fall 1973, but they soon became working colleagues through the American Library Association's (ALA) Preservation of Library Materials Committee (PLMC). Beyond Darling's newness to the field, there are other reasons why she and Banks had not met before. They worked in similar professional realms, but ones that were not yet fully collaborating with one another. The cross-pollination of the two fields was fairly nascent in 1973. The few book conservators in the US found their professional colleagues in the new AIC, and even more prominently in the Guild of Book Workers. The new RLG preservation managers worked primarily with each other and through the ALA's PLMC. Conservators ran among conservators; the handful of preservation managers—all librarians—cohered in their mandate to build preservation programs for their individual libraries and the RLG consortium. Hence, Darling had no idea that Banks developed and taught in 1971 the first graduate library and information science–based course on conservation in the US at the University of Illinois—the exact course she envisioned in her memorandum to Dean Darling. While Pamela Darling and Belanger noted that they "could not think off-hand of anyone with the breadth of background needed to put together the kind of basic course that must be the first step in developing a thorough program," John Baker, Darling's supervisor who was copied on her memorandum, could. He knew Banks (Darling 1973).

By 1974 in New York City, the library conservation scene was gaining momentum in no small part due to Pamela Darling's and John Baker's initiative. Invited by Baker, in May 1974 Banks spoke on the topic of the library environment to the Metropolitan New York Library Council (METRO), a large consortium chartered by the New York Board of Regents in 1964 (Baker 1974). Susan Thompson (fig. 5), an assistant professor in the SLS actively interested in the topic of preservation, attended the talk and afterwards spoke with Dean Darling about "the conservation program." She wrote to Banks: "[H]e says he would like very much to know more about what you think such a program should be and about the possibilities of funding. Needless to say, Columbia itself has no funds for expansion, but we are interested in the idea of offering training for conservators" (Thompson 1974). In response, Banks, armed with the range of data, curricula, and proposals he had prepared in recent years for the Council on Library Resources (CLR), sent a version to Thompson, suggesting that perhaps there could be coordination between NYU's Conservation Center of the Institute of Fine Arts and Columbia (Banks 1974).

Fig. 5. Pamela W. Darling, 2014. Courtesy of Pamela W. Darling.

A year later, the RLG Preservation Committee convened for the first time in spring 1975; Edwin Williams, Harvard's longtime associate university librarian, chaired the committee, alongside member representatives John Baker, Pamela Darling, and Gay Walker (Yale University). They were a tight, focused team mandated to build preservation programs with a primary focus on coordinating the microfilming of brittle collections. Of the range of topics the committee tackled, Darling consistently articulated the need to institute formal training to build the new profession. By the time the committee met in May, she had drafted an early planning report suggesting that by spring 1976, a year later, a task force addressing joint training programs should author "a detailed long-range plan, including subjects and skills to be included, cost estimates and resource people, and a recommendation on the appropriate mechanism for implementing and sustaining an on-going training program" (Darling, May 1975). Darling commented that Columbia's SLS expressed interest in cooperating on the development of preservation education programs, suggesting that RLG might wish to invite a representative from the school to serve on the task force. By winter 1976, with no task force in sight, she penned a memo to the committee elaborating her thoughts on a potential consortial project:

> *The possibility of combining preservation program development in the consortium context with the development of a full-scale educational program in library conservation in cooperation with RLG's 'member library school' is especially appealing. The shortage of trained people is a critical part of the preservation problem, not only with RLG but in the profession at large. Such a program would therefore meet a tremendous need, would be attractive to foundation support, would enhance RLG's prestige, etc." (Darling, February 1975)*

While the RLG did not create a training task force, Darling, leaving no stone unturned, pursued other avenues. In a project she and John Baker guided, METRO hired Banks in 1976 to conduct a feasibility study on the potential for establishing a cooperative conservation center for New York City's libraries. Given that Banks would be in the city in summer 1976 to undertake this study, Dean Darling hired him to teach a course for the SLS, "Preservation of Library Materials," and gave him an office in the school as his base for teaching and research.

In the METRO study, Banks outlined a training program for conservators, one he proposed would be associated with the envisioned METRO cooperative conservation center. Since there were few conservators in the country educated to handle the kinds of treatments libraries might send to the center, Banks suggested, expediently, that a METRO conservation operation liaise with a library and information science program. While he was unclear on exactly how such an educational undertaking might work, he suggested "elements in the city" that might, together, comprise a program, including "the history of the book and descriptive bibliography courses at the Columbia University Library School, the general conservation and materials science knowledge available at NYU's IFA-CC…." (Banks 1976, 5). As Banks stated in his report, outside of Washington, DC, New York City was the most logical place for a conservation center given its large aggregation of rich research library collections (Banks 1976, 2). Combined with forthcoming NCAC reports outlining the educational needs of library and archives conservators, the METRO report documented that New York City provided fertile grounds for such an educational initiative.

Pamela Darling, excited by Banks' ideas, wrote to Richard Darling in November 1976: "Dreadful money matters aside, there could be real benefit to SLS from this." Referring to "our" programs, she proposed a significant role for Columbia's SLS:

> *I would dearly love to have the consultative/educational phase of this plan located here, combining the resources of the Libraries and the Library School. If Paul Banks were director (I have the distinct impression he'd like to be) we would have a tremendous resource and support for accelerating the development of our own programs.*
>
> *If METRO decided to go ahead, I hope we might be in a position to make an early offer to be the host institution.*
>
> *If METRO decides against it, we should pursue through RLG. (Darling 1976)*

Her desires clear, Pamela Darling's ideas and passion for the topic found resonance with Dean Darling.

In 1977, the SLS solidly staked its interests in preservation education. On the heels of the METRO study, Susan Thompson and the Darlings wrote a federal grant to hold a four-week preservation institute in the SLS. Funded by the U.S. Office of Education under Title IIB of the Higher Education Act, the institute was designed to "prepare experienced librarians to plan, organize, and administer comprehensive preservation programs in the libraries in which they are employed" (School of Library Service, Columbia University 1977). The institute took place in the SLS from July 10 to August 4, 1978, and 12 mid-career librarians from across the US attended (Patterson 1979, 3).[3] Directed by Thompson, and with Banks and Pamela Darling as the primary instructors, the four-week course, in effect, substantiated intellectual links between the conservation field, library preservation administration, and the LIS discipline, while also demonstrating the SLS's interest in and ability to educate in this new intellectual arena. Moreover, it brought New York City–based preservation professionals together as instructors, demonstrating not only the wealth of resources in the SLS, New York City, and a train ride away, but also their interest in working together in a new undertaking.

Convinced of a possible role for conservation and preservation education in the SLS and armed with enough documentation to assert the SLS's claim on the new specializations, one month after the workshop concluded Dean Darling submitted a successful planning grant proposal to the NEH to conduct a study for the establishment of training programs in the SLS for conservators and preservation administrators (School of Library Service, Columbia University 1978). Banks, working with Pamela Darling and SLS colleagues, designed a new curriculum for educating library and archives conservators and PAs. With primary funding from the NEH and the Mellon Foundation, the SLS unfurled the dual-track Conservation Education Programs and courses began in fall 1981. Darling taught the preservation administration course in the new curriculum from 1982 until 1986.

Pamela Darling left Columbia in 1980 to assume a two-year position at the Association of Research Libraries as Preservation Specialist, where she and Duane Webster designed the Preservation Planning Program to aid US research libraries in developing preservation programs. From 1982 to 1985 she was Special Consultant to the National Preservation Program of the Library of Congress. During the last year of her tenure at LC, she was Consultant to the New York State Library's Conservation and Preservation Program (fig. 5).

ACKNOWLEDGMENTS

Cathleen A. Baker, editor of The Legacy Press, published the author's book (*Mooring a Field: Paul N. Banks and the Education of Library and Archives Conservation*, 2019), which prompted some of the additional research in this paper (*Mooring a Field: Paul N. Banks and the Education of Library and Archives Conservators*, published in 2019). The now numerous monographs recounting the history of the book and paper conservation specialization and related subjects are due to Cathy's boundless energy and vision. As always, thank you to Preservation and Conservation Division colleagues at the

Harry Ransom Center. Special thanks to Dr. Stephen Enniss, director of the Ransom Center, for his encouragement and support of professional development and engagement.

NOTES

1. This article includes revised portions of published work in Cunningham-Kruppa, Ellen. 2019. Mooring a Field: Paul N. Banks and the Education of Library and Archives Conservators. Ann Arbor, MI: The Legacy Press.

2. The *New England* Document Conservation Center was incorporated as the *Northeast* Document Conservation Center in 1980.

3. Student attendees were: Hilda Bohem, University of California, Los Angeles; Helen Slotkin, Massachusetts Institute of Technology; Sandra Turner, Denver Public Library; Paul Koda, University of North Carolina at Chapel Hill; Peter Hanff, University of California, Berkeley; Virginia Adams, Providence Public Library; Carolyn Harris, University of Texas at Austin; Pearl Berger, YIVO Institute; Robert Patterson, University of Wyoming; Karen Esper, Case Western Reserve University; Robert Schnare, U.S. Military Academy; and, Sue White, Princeton University.

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A Proven Case of Repainted Ming Dynasty Chinese Ancestor Portrait Painting

INTRODUCTION

Conservation of the Tsai Fu-Yi portrait painting was conducted over five years and was overseen by the Cultural Affairs Bureau of Kinmen County. The project included work in three main subject areas: art history and scientific studies from 2017 to 2018, conservation treatment from 2019 to 2020, followed by exhibition and long-term storage. After being temporarily stored in Taiwan after treatment, the Tsai Fu-Yi portrait painting was shipped back to Kinmen at the end of 2021 and exhibited in his hometown in February 2022.

Tsai Fu-Yi was born in Kinmen, a small island very close to the southeast coast of China, about an hour's flight from Taipei. Kinmen was known for its military position, cultural heritage, and kaoliang liquors. It has deep and abundant cultural and historical links to China.

Historical research was conducted by Professor Lu, Tai-Kang and Shao, Chin-Wang, the Tainan University of the Arts, and the research team. Tsai Fu-Yi was born in 1576, died in 1625, and was an intelligent and clever man. He was not only a diligent political governor who loved his people but also served a five-province governor position in the history of the Ming Dynasty. This Ming Dynasty-style Tsai Fu-Yi portrait painting was presumably completed between 1625 and 1644, nearly 400 years ago (Lu and Shao 2017, 157–158).

According to the Tsai family members of this generation (Lu and Shao 2017, 187–195), they would hang this portrait painting for worship on the winter solstice and the death anniversary of Tsai Fu-Yi in October every year. Hundreds of years of this practice gradually damaged the painting, and the scroll became too brittle to hang. Sometime between 1950 and 1960 (Lu and Shao 2017, 194), a local Kinmen resident assisted the Tsai family with repainting a large area using modern paint in the red robe and the white background. These repainted areas had become hardened and brittle with time. After repeated hanging and rolling, the newly painted areas caused new serious damage. The Tsai family treasures this portrait so much that in 1990 the family members decided to replace the hanging scroll portrait with an A3-size framed color photo for their worship ceremonies (fig. 1). At the same time, they gradually lost their family tradition of hanging the Tsai Fu-Yi portrait painting for worship.

Fig. 1. The framed A3-size Tsai Fu-Yi photo that the Tsai family used to substitute for the original hanging scroll during ceremonies.

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

Fig. 2. Images before treatment under normal light, transmitted light, and UV light.

TREATMENT

In this conservation project, there were several goals to achieve and challenges to face, including:

1. Identify a suitable solvent application method to control the direction of the softened or dissolved paint and prevent it from spreading to other areas or bleeding into the original pigment layer or paper fibers.
2. Determine whether it was possible to remove the repainted layers without damaging the original pigment.
3. Remount the restored portrait in screen format in order to prevent it from curling again, or remount it in the same hanging scroll format as the original; avoid possible damage occurring to the hanging scroll during the long-term storage and re-rolling.
4. Conduct the preservation of this precious portrait painting while considering the traditional portrait worship ceremony for the Tsai family.
5. Create a uniquely designed frame that takes into account the exhibition, shipping, and rotation between the original and replica paintings for the local museum without conservators or professional art handlers.

All these challenges needed to be completed simultaneously (figs. 2, 3).

Compared with many other traditional ancestral portrait paintings, the treatment of this painting was different and more difficult due to the coated layer of modern paint over the original mineral pigment. No one on the team had encountered a situation like this before (fig. 4).

Based on the previous research results (Lu and Shao 2017, 140–158), this artwork had been repaired at least twice before, and the newly applied modern paint on the surface was assumed to be polyurethane. According to the previous testing results and spot tests before practical treatment, as well as paint samples that were soaked and tested, a suitable solvent or treating method was not found (fig. 5).

However, during the process of removing the tapes, it was observed that the repainted areas reacted to ethanol after roughly 20 to 30 minutes. After the tapes were removed, the paint was softened and swelled slightly. Following surface cleaning and wet-cleaning of the repainted paint with pure water, different ethanol concentrations and various solvent application methods were tested. By observing the reflectiveness of the paint surface, it was possible to determine the appropriate time to remove the paint in this area (fig. 6).

Test results found that 95% ethanol in a vapor state was effective at softening the paint without dissolving it, which could cause smearing. A petri dish was used as a vapor chamber, with blotter paper holding the ethanol. After several

Fig. 3. NIR and raking-light images before treatment.

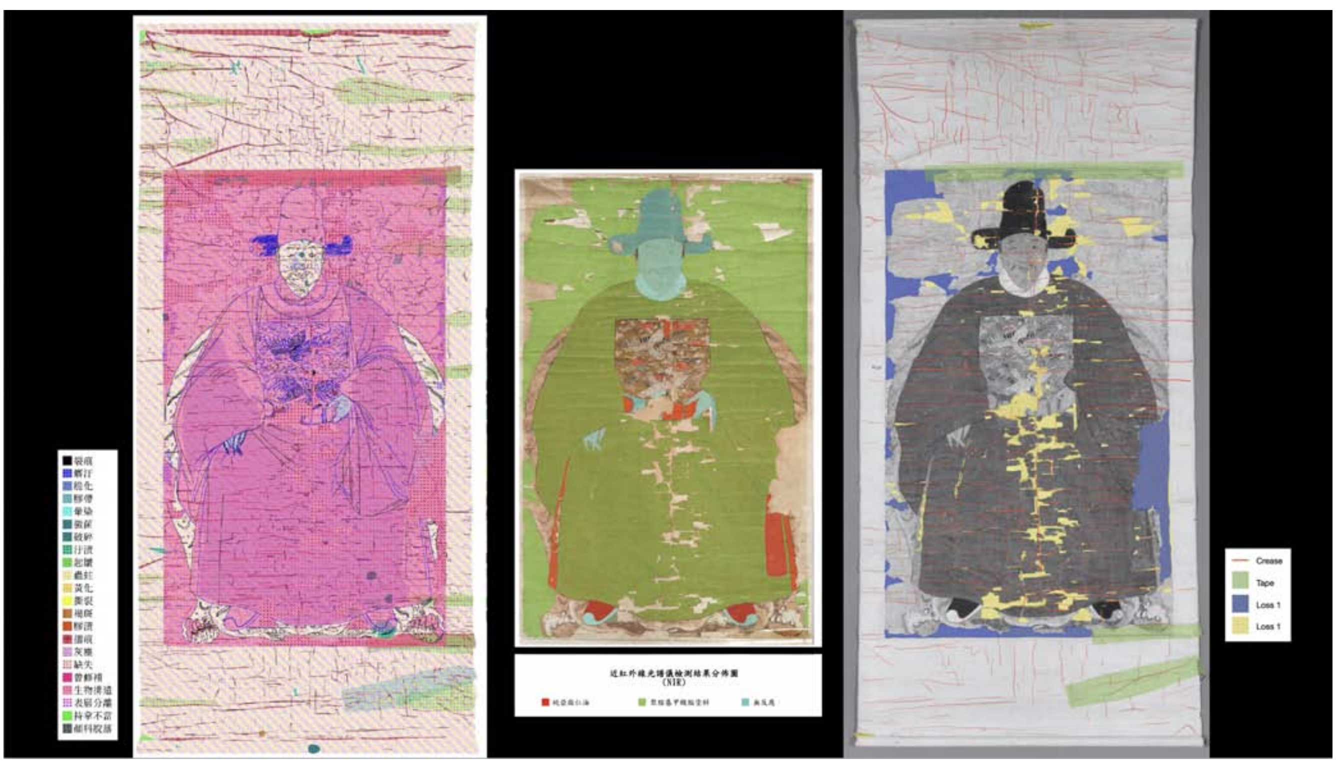

Fig. 4. Mapping of condition. The images on the right and middle are from the previous research report by Professor Lu and Shao in 2020. The middle image shows overpainted areas on the painting in green.

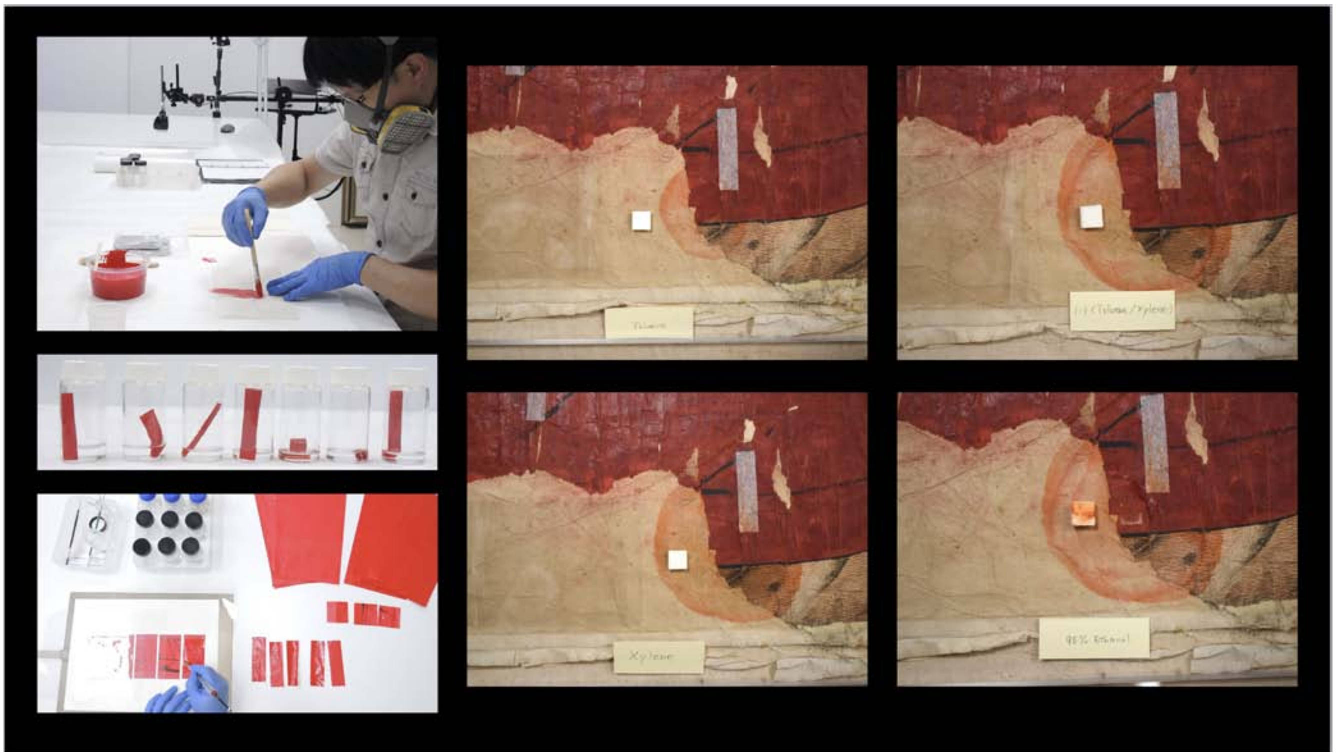

Fig. 5. Preliminary paint sample preparation and dissolving tests with different solvents.

Fig. 6. Overpaint dissolving tests in different concentrations of ethanol. In the lower left and right, the paint is dissolved and glossy on the surface indicating the effect of ethanol.

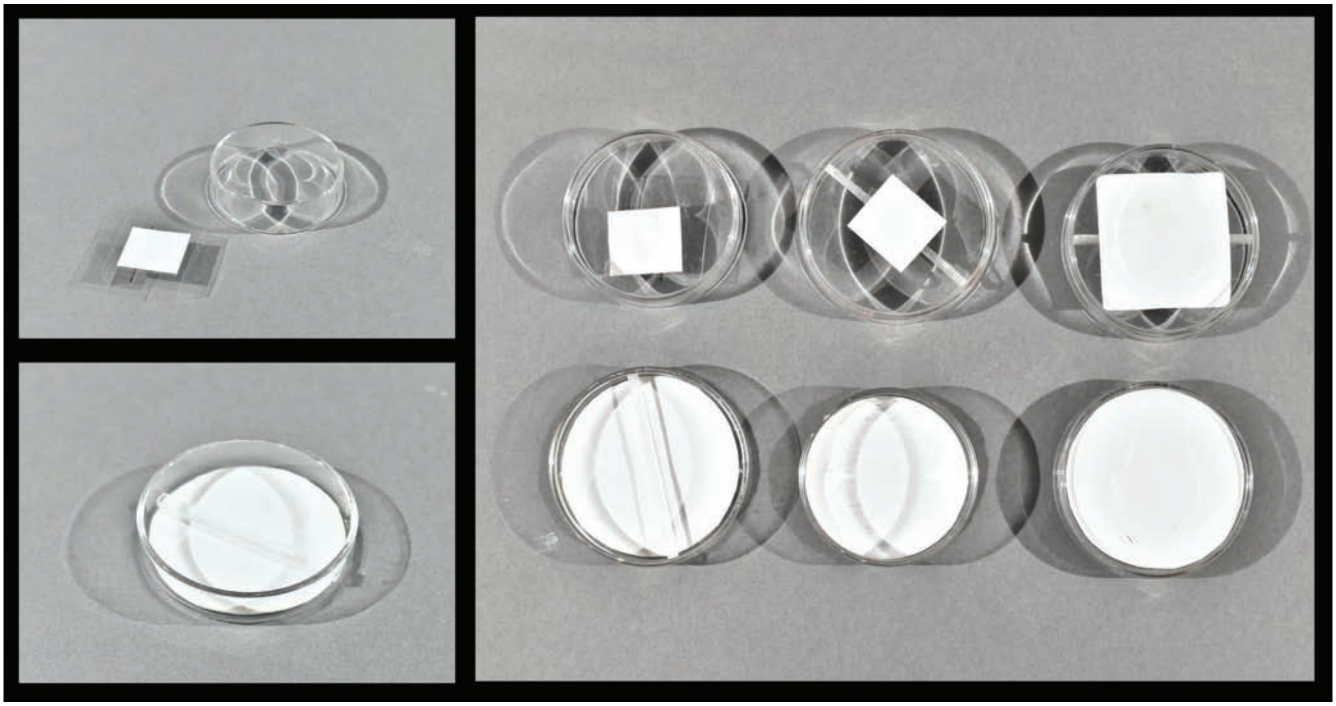

Fig. 7. Different types of lids were used for ethanol vapor in treatment.

improvements to the design, the effectiveness of the reaction apparently improved (fig. 7). During the paint removal, the waiting time for different areas varied—generally, 8 to 45 minutes. A cotton swab dipped in ethanol was then used to slowly and repeatedly remove the paint in a rolling manner. During removal, it was also necessary to avoid downward force, which would risk compressing the softened paint into the original pigment and paper fibers.

Eventually, the process revealed the painting's original beautiful red cinnabar color that had previously been observed under XRF analysis. And the detailed Ming Dynasty-style ink drawing lines that were previously only visible in IR images were at last revealed (fig. 8). This response to the Tsai family's inheritance record of this painting and the stories of their ancestor Tsai Fu-Yi confirms the inferences of art historians on the creation period of this portrait (figs. 9, 10).

The repainted layer not only covered the original painting but also hardened the paper and caused the damage and curling conditions to become severe. After removing as much of the repainted surface as possible, ethanol was used to clean the repainted area several times. At this time, blotting paper placed below the painting was used to reduce residues of the modern paint underneath the painting. However, a small amount of paint remained in the pigment and paper fibers, which could be seen under ultraviolet inspection.

The remainder of the treatment process included removal of old backing layers, washing, adjusting the painting

Fig. 8. Ming Dynasty–style ink drawing lines are revealed under the IR image. The yellow lines indicate the locations of those lines.

Fig. 9. Surface paint removal using cotton swabs. The original drawing lines appeared after the red overpaint was removed in the image on the right.

fragments to their correct positions, and re-lining. Acrylic-dyed pineapple-fiber paper was used to perform inlays from the front of the painting to replace lost areas of the portrait (fig. 11).

Fig. 10. The overpainted ink drawing lines (green arrow) were removed and then revealed the original lines (yellow arrow).

While the portrait was originally a hanging scroll, there were debates about remounting the painting in this format as continued rolling could result in the cracks lifting again. Initially, remounting the portrait in a screen format was considered a more appropriate option. However, after many discussions with the project committee, the painting was remounted into the same hanging scroll format as its original style but stored unrolled. Xuan paper was used as a decorative material, similar to the original mounting material, then two layers of pineapple-fiber Xuan paper were applied for backing to provide better strength for hanging.

A protective wooden frame was designed, made of a combination of two wooden lattice window boards, acid-free museum mat boards, and silk mounting fabric; the hanging scroll was set on the lower board. For display, only the upper board needs to be removed. If the painting needs to be rolled in the future, it can be easily removed from the display frame (fig. 12).

A cushioned wooden box was built, which can safely ship the painting long-distance from Taipei to Kinmen and move between storage and exhibition halls in the museum for exhibition rotations.

REPRODUCTION

The Tsai Fu-Yi portrait painting has unique historical value. It is likely the only Ming Dynasty ancestor portrait painting kept in private collections and still used in actual ancestor worship ceremonies in the Taiwan area.

Fig. 11. The treatment process of the painting. A: Backing paper removal. B, C: Lining paper removal. D: Adjusting the painting fragments. E: Lining. F: Infilling losses.

During the treatment period, this painting was designated a significant treasure under the Taiwanese Cultural Heritage Preservation Act. It is the first significant treasure of cultural heritage in Kinmen and has worthy meanings to the Tsai family and Kinmen. The Cultural Affairs Bureau of Kinmen County provided extra government resources, with the expectation to preserve and display this painting and to continue the Tsai family ancestor worship traditions. Therefore, as required in the project, four reproductions were made after treatment: three returned to the Tsai family, and one retained for display rotation.

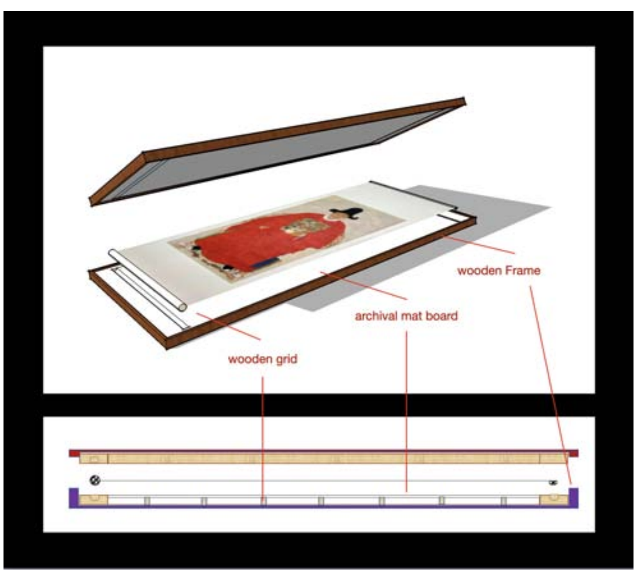

Fig. 12. Structure of the storage and display frame.

A professional reproduction team assisted us in scanning and printing the painting. A Cruse Synchron Table Scanner 4.0 CS295 and an EPSON SureColor P-9000 large-format printer were used to scan and print the reproduction paintings. The reproductions were mounted in traditional Chinese hanging-scroll format.

Every step of reproduction was carefully undertaken, and it initially seemed like the reproductions were perfect copies of the original.

An instructional session for the Tsai family was held in Kinmen to introduce and explain the conservation treatment process and to educate them on how to properly roll and unroll hanging scrolls. One reproduction painting was brought to the session as teaching material. More than 20 elder Tsai family members participated in the class, and all of them had seen the Tsai Fu-Yi painting when they were younger.

During the course, one of the family elders said to the others that the reproduced Tsai Fu-Yi seemed "chubbier" than what he remembered from childhood. Others

Fig. 13. Display of the reproduction of the Tsai Fu-Yi portrait painting.

reassured him it was because he hadn't seen the painting in so long and remembered it incorrectly. The reproductions are printed on machine-made paper. In this case, with the traditional Chinese wet-mounting process, the painting image swelled by about 0.9 to 1.4 cm overall. Thus Tsai Fu-Yi's face was in fact "chubbier"—it expanded by approximately 0.3 cm. The family elder had an incredible memory.

A different printing and mounting method was sought to prevent this distortion of the portrait. Digital editing of the images was considered, as well as reducing the water levels during the mounting process. Eventually a hot-mounting process was adopted and no dimensional changes occurred (fig. 13).

Paper-based artwork reproductions without wet processing were unfamiliar to the team. It is recommended to avoid the wet-mounting method for reproducing paintings. Digital calibration of the image before printing may also be an efficient way to reduce deformation. The aim was to represent the appearance of the artwork and to preserve people's memories and emotions.

MOUNTING AND DIMENSIONS

In the early stage of treatment, the authors uncovered pencil drawing lines under the mounting material on the edges of the painting. The authors postulated that the pencil lines may have been drawn according to a traditional Chinese measurement system, the Luban Ruler.[1]

The Luban ruler is a type of carpenter's ruler named after Lu Ban, a Chinese carpenter during the Zhou Dynasty. It is still commonly used today. Besides measuring distances, the Luban Ruler is divided into sections to indicate whether the measured distance is auspicious or not.

The window size marked by the original pencil lines indicated an "auspicious" measurement according to the Luban ruler, so the reproductions were remounted at this original size; thus, the mounting size of the original painting was enlarged to preserve and present the entire painting but also to align with this traditional custom (fig. 14). The size of the display frame and outer wooden box were all selected to accommodate the "auspicious" measurement. For ancestor portraits, conservation not only preserves its physical materials but also concerns traditional beliefs (fig. 15).

EXHIBITION

Beginning in February 2022, the restored Tsai Fu-Yi portrait painting was exhibited in his hometown, Kinmen. The original painting and reproduction were exhibited and rotated regularly in a newly designed, environmentally controlled gallery, along with related research and treatment information. The exhibit allows the public to appreciate this ancestor portrait hanging scroll (fig. 16).

Fig. 14. The Tsai Fu-Yi portrait painting was mounted in new dimensions and exhibited in Kinmen.

Fig. 15. Re-hanging the portrait painting for the worship ceremony in the Tsai ancestral hall.

CONCLUSION

Conservation of the Tsai Fu-Yi portrait painting revealed its original, beautifully ink-drawn lines and bright, cinnabar red color.

The Tsai family received an almost identical reproduction painting of the original to worship, reinstating the family ceremonies that were once interrupted. Descendants of the Tsai family and people in Kinmen can regularly visit the Tsai Fu-Yi exhibition to see the painting and learn about its conservation (fig. 17).

Through the conservation and reproduction of this portrait, the cultural significance and interest in the Ming Dynasty governor Tsai Fu-Yi has been renewed. Cultural activities relating to Tsai Fu-Yi will continue to be carried out by Tsai descendants and the people of Kinmen.

The Tsai Fu-Yi portrait painting was registered as a significant antiquity in 2020 by the Ministry of Culture of Taiwan. This conservation project connects not only art history research and conservation but also the government, cultural heritage, and residents.

ACKNOWLEDGMENTS

Cultural Affairs Bureau of Kinmen County, Taiwan
Liu-Bin Tsai, Descendant of Tsai Fu-Yi

Fig. 16. Rotation of the original hanging scroll and reproduction.

Fig. 17. Tsai Fu-Yi portrait exhibition in his hometown, Kinmen.

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Easi Graph Company
Eastward Artifact Frame Design Company

NOTE

1. For further information on the Luban ruler, please see: Ruitenbeek, Klaas. 1993. *Carpentry and Building in Late Imperial China: A Study of the Fifteenth-Century Carpenter's Manual* Lu Ban Jing. Leiden; New York: E. J. Brill.

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Tsai Fu-Yi Portrait Painting Introduction. "https://cabkc.kinmen.gov.tw/asset?uid=75&pid=9"

Tsai Fu-Yi Portrait Painting Treatment video. "https://www.youtube.com/watch?v=vpkEybqRLgs"

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T.H. Saunders Sample Book: A Treasure Trove of 19th Century Papers

INTRODUCTION

In 1855, the English papermaker Thomas Harry (T.H.) Saunders represented England at the *Exposition Universelle des produits de l'agriculture, de l'industrie et des beaux-arts*, in Paris (*Paris Universal Exhibition* 1855*,* 214.). Specifically for the event, T.H. Saunders & Co. created and exhibited a paper sample book, *Illustrations of the British Paper Manufacture*, containing 151 paper samples divided into three categories: papers made by hand, papers made by machine, and special papers. T.H. Saunders & Co. was well known for producing watermarked papers that were used for banknotes, cheques, stamps, and other official records.

History of T.H. Saunders & Co.

From the 1830s to the time of his death in 1870, T.H. Saunders operated a well-known and prosperous paper manufacturing company with six papermills located throughout England. Beech and Rye Mills were located at High Wycombe in Buckinghamshire; Phoenix, Hawley, and Darenth Mills were located at Dartford in Kent; and Sunridge Mill was located at Sevenoaks (Cohen 1988, 3). By 1880, the Phoenix Mill was likely the largest paper mill in the country, and it was one of the major industrial buildings in southeast England at the time (Cohen 2004).

T.H. Saunders & Co. papers were prized for their high quality and the company was renowned for producing extraordinary watermarked "exhibition sheets." The quality of the paper was recognized as T.H. Saunders & Co. was awarded 12 prize medals at international exhibitions between 1851 and 1881, including gold medals at the 1867 and 1878 Paris exhibitions (*The Paper Mill Directory of the World* 1884, 362; Cohen 2004).

Despite the company's success, relatively little is known about T.H. Saunders & Co. today. According to Cohen (1998, 4), it appears that the T.H. Saunders & Co. 19th century business and archival records were destroyed at some point between 1984 and 1985. However, the legacy of this company remains acutely visible in the *Illustrations of the British Paper Manufacture*. In addition to the vast array of paper samples (including papers for drawing, watercolor, photography, tracing, blotting, newspapers, security papers, colored papers, and artisanal "exhibition sheets" with extremely detailed "light and shade" watermarks), the book includes illustrated narrative pages where histories and descriptions of paper production are accounted. It is unknown how many sample books were produced for the Universal Exposition in Paris, but this lavish sample book would have been costly to produce. Munsell (1870, 127) claims that "the work could not have cost less than a thousand dollars." It is unclear in this text if "the work" refers to a single volume or the overall sample book production. As of July 17, 2022, the CPI Inflation calculator listed on its website that the equivalent purchasing value of $1,000 USD in 1870 is approximately $22,500 USD.

Illustrations of the British Paper Manufacture

Illustrations of the British Paper Manufacture was produced as a three-volume set that was divided into five classes of papers. Volume One contained 151 paper samples and the first three classes of paper: Class A – papers made by hand; Class B – papers made by machine; and Class C – special papers (Saunders 1855) (fig. 1). These papers were all produced at the mills of T.H. Saunders & Co. (Cohen 2004). Volume Two included Class D papers containing samples that were the raw materials of other manufacturers, and Volume Three included Class E papers, containing samples of various packing and wrapping papers (Royal Society of Arts 1856, 295). There are currently 12 known copies of Volume One.[1] Volumes Two and Three are thought to be unique creations that are now housed at the National Art Library at the Victoria and Albert Museum in London (Cohen 2011, 11).

In 1972, the only known conservation treatment relating to one copy of the sample book was published in the *Bulletin of the American Group, International Institute for Conservation* by Paul Banks. The article describes an extensive conservation treatment to the Newberry Library copy where the book was

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

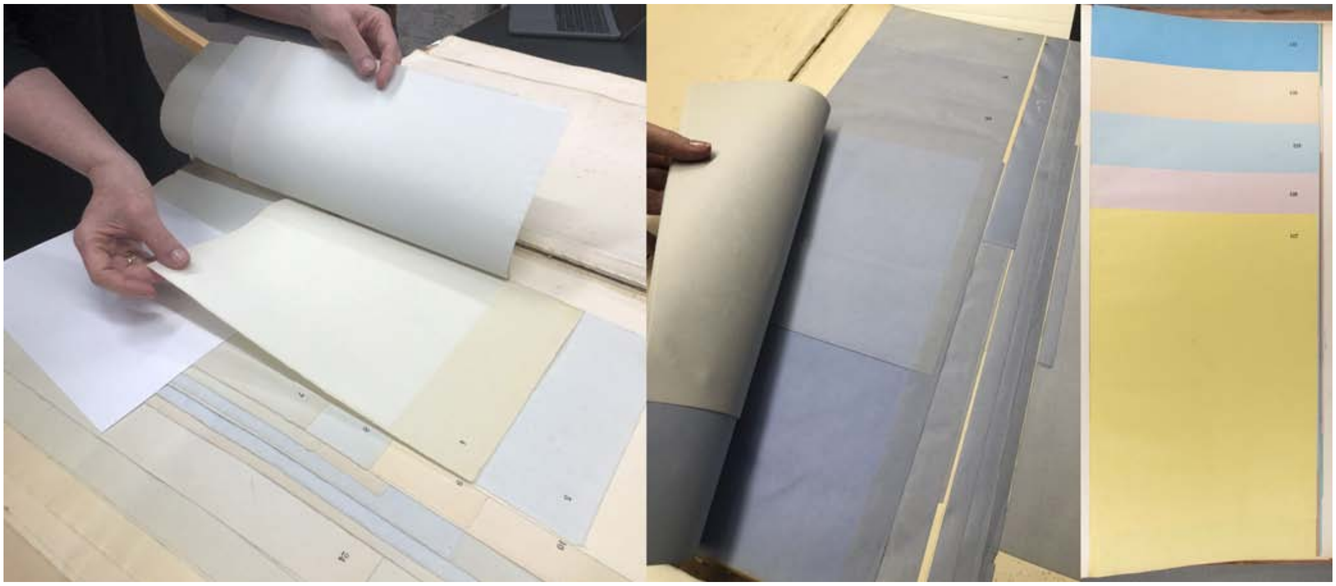

Fig. 1. Colored paper samples from Class A (left), Class B (middle), and Class C (right). From *Illustrations of the British Paper Manufacture,* Queen's University, W.D. Jordan Rare Books and Special Collections, Rare Books Collection, FF TS1105. S2.

disassembled, the papers deacidified with magnesium bicarbonate, and then rebound (Banks 1972, 88).

The Queen's University copy

The W.D. Jordan Rare Books and Special Collections at Queen's University (Kingston, Ontario, Canada) holds a copy of the first volume of *Illustrations of the British Paper Manufacture* (fig. 2). The book was donated to the university on June 23, 1879. This sample book is an untreated treasure trove of full-size paper sheets dating from approximately 1846 to 1855, as evidenced by the dated watermarks. It contains over 151 naturally aged and untreated full sheet samples, 40 of which have dated watermarks.[2]

Fig. 2. Robin Canham examines machine-made paper samples numbered 43 through 46 in *Illustrations of the British Paper Manufacture*, at the W.D. Jordan Rare Books and Special Collections, Queen's University Library.

The Queen's University copy is a compelling artifact that allows for the examination of paper production from a single, prosperous, Western paper manufacturer during the 19th century—a period of mechanization when both handmade and machine-made papers were being produced. It is a time capsule of naturally aged paper samples and because the sample sheets are in a bound format, they were unaltered by light exposure. All sample papers are tipped-in to a guard along the left edge of the sheet or along the center fold line depending on the sample sheet's size.

The book is large, measuring approximately 69 cm tall, 50 cm wide, and 7 cm thick at the spine. The large format was likely dictated by the largest sample sheet—sample 124, which is designated as a "paper for newspapers" in the index. When unfolded, the newspaper sheet measures approximately 83 cm tall by 101 cm wide.

In addition to the paper samples, the book includes 23 leaves of text. The text is printed in English (in the left column) and French (in the right column) and is encircled in a floreated border that includes beautifully illustrated raw materials for paper and paper-like production including flax, cotton, hemp, palm, and papyrus. The text describes the history, materials, process, and machinery involved in the manufacture of handmade and machine-made papers. The sample book was printed in London by Waterlow and Sons and bound by Pamphilon & Brookwell, located at 64 Berwick Street (Saunders 1855).

The Queen's University copy is almost complete. The volume is missing samples 115, 116, and 117, each of which are outline and shade watermarked papers. In addition, seven sheets included in the colored paper section have been torn in half with the left side of these sheets removed.

THE T.H. SAUNDERS PROJECT

This remarkable paper sample book forms the basis for our multiyear T.H. Saunders Project. *Illustrations of the British Paper Manufacture* richly illustrates mid-19th century Western paper production during a period of mechanization and hand-crafted paper manufacture. The sample book contains textual and material information that illustrates a time of transition in papermaking materials and technology. The goals of this multiyear project will include a phased approach to the full technical examination, conservation, and digitization of the sample book. The objectives of the research project include:

- expanding our knowledge of 19th century paper production, leading to a more nuanced characterization of papers in order to understand their degradation mechanisms;
- producing a technically rich, digital reference tool to compliment the digital surrogate and physical artifact; and,
- creating teaching opportunities by engaging conservation graduate students in the research processes.

The first phase of the research project commenced in 2021 and involved the digitization of each text plate and documentation of all watermarks to minimize handling and increase researcher access. Imaging of individual sample sheets has not yet been completed as the samples are tipped-in along the left edge or center fold. This makes useful imaging challenging. Descriptive and technical information was collected in a spreadsheet and includes detailed information about each paper sample, including the size, watermark, color, thickness, paper formation, condition, and more. In phase one, preliminary fiber identification began using a HIROX high-resolution digital microscope to identify paper fibers in both handmade and machine-made papers (fig. 3). This is a nondestructive method of examination, as no paper sampling is required.

Phase two of this project will include continued technical examination and conservation. At this point, minimal treatment is envisioned to maintain the artefactual value of the book. Development of metadata and the exploration of Islandora 8 and other open-source digital asset management tools to support an accessible digital sample book will be undertaken. The research team also plans to compare the Queen's University copy to as many of the other known sample books as possible. Comparison of sample condition, description of the unnumbered specimens in Class C, and provenance and storage history will enhance understanding of each sample book and the aging characteristics of mid-19th century English papers.

Phase three of this project is currently in development and will include the creation of a technically rich digital reference tool to accompany the digitized sample book. Research into linked data opportunities will also be explored.

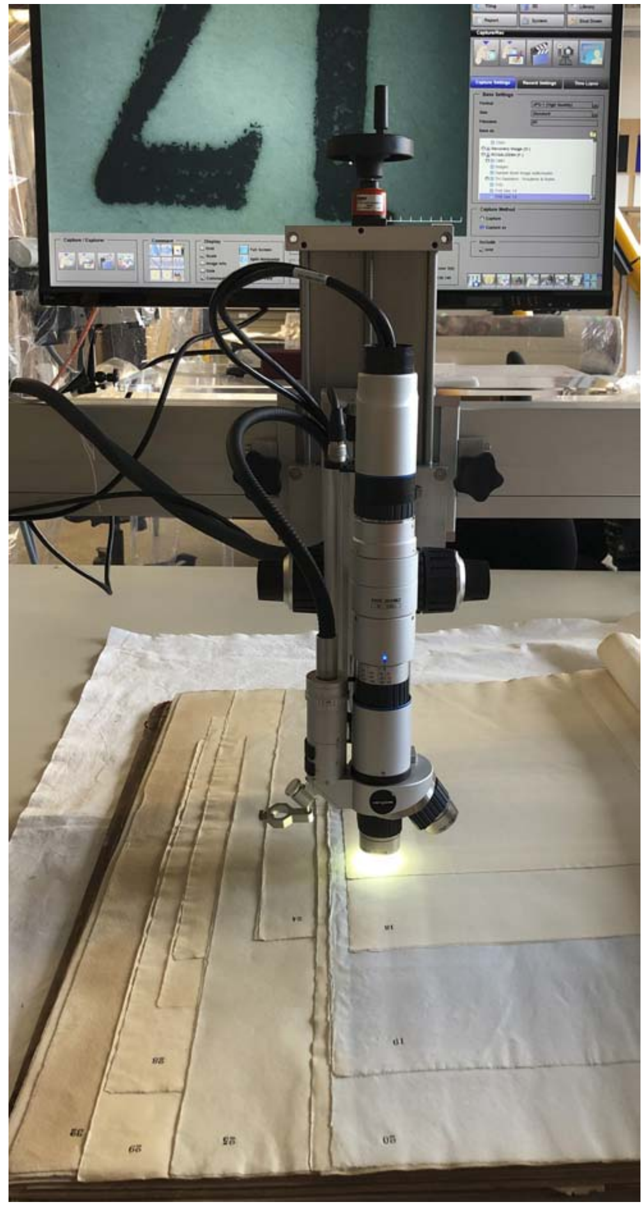

Fig. 3. A photograph detailing the setup of the HIROX digital microscope as handmade paper sample number 17 is examined.

TECHNICAL INVESTIGATION

Our initial examination of technical information focused on an extensive research review of 19th century literature describing patent, cheque, and colored papers.

Patent and cheque papers

Patent and cheque papers were designed to thwart forgeries. Forgery appears to have been rampant in the mid-19th

Fig. 4. Transmitted light photograph of Glynn & Appel's Patent security paper, sample 103. From *Illustrations of the British Paper Manufacture*, Queen's University, W.D. Jordan Rare Books and Special Collections, Rare Books Collection, FF TS1105 .S2.

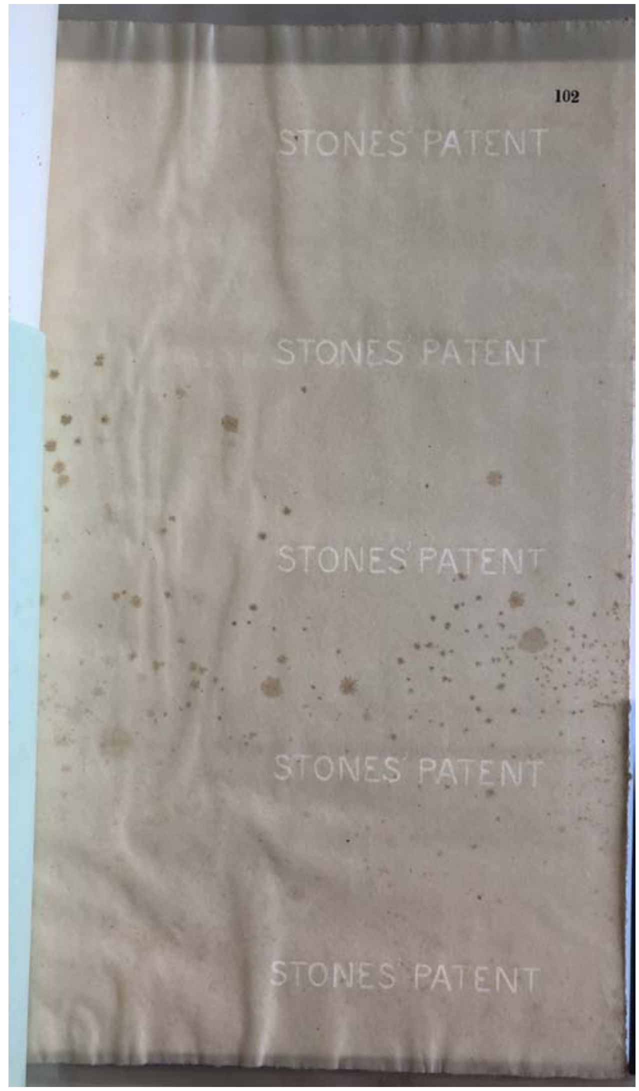

Fig. 5. Transmitted light photograph of Stones' Patent security paper, sample 102. From *Illustrations of the British Paper Manufacture*, Queen's University, W.D. Jordan Rare Books and Special Collections, Rare Books Collection, FF TS1105 .S2.

century in part due to the introduction of anastatic printing in 1841. Anastatic printing enabled reproduction of hundreds or thousands of copies of a wide range of paper objects including bank notes, cheques, bank drafts, and other financial papers. The November 1852 issue of *Scientific American* included an article written by the British Association for the Advancement of Science where the anastatic process was outlined and "patent papers for the prevention of piracy" (59) were discussed including Glynn & Appel's patent (fig. 4) and Stones' patent paper (fig. 5).

In the 1851 Great Exhibition, T.H. Saunders & Co. introduced papers designed to prevent piracy or forgery. *The Crystal Palace, and its Contents; Being an Illustrated Cyclopaedia of the Great Exhibition of the Industry of All Nations* notes that T.H. Saunders and Co. papers were awarded a prize medal for Stones' patent cheque paper, of which Saunders was the patentee (1852, 143). Stones' patent paper was described as providing "great improvement" because it "render[ed] a paper perfectly resembling ordinary writing paper secure against the removal of inks by chemicals, as, on the application of the usual means for dissolving ink, the proof of its having been tampered with immediately becomes manifest, the paper becoming indelibly discolored" (*The Crystal Palace, and its Contents* 1852, 143). In *The Bankers' Magazine and Journal of the Money Market*, an article also describes Stones' patent paper and asserts "specimens we have tried, produce a curious effect on the application of the usual means of dissolving ink; a violent discoloration takes place, going completely through the paper, and a well-defined rim remains, indicating irradicably that the paper has been tampered with" (1851, 296).

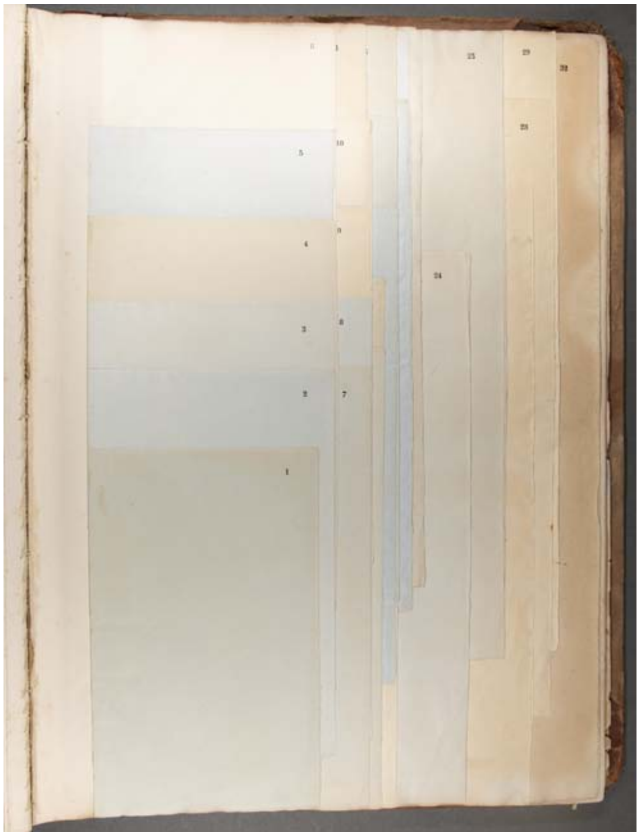

Fig. 6. A selection of handmade papers in Class A. From *Illustrations of the British Paper Manufacture*, Queen's University, W.D. Jordan Rare Books and Special Collections, Rare Books Collection, FF TS1105 .S2.

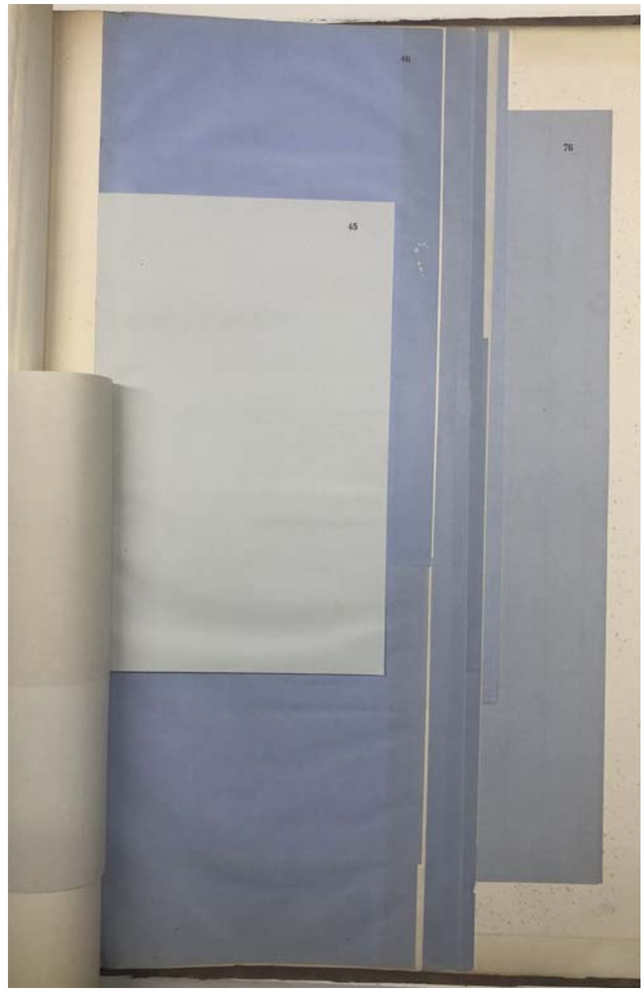

Fig. 7. A selection of blue colored machine-made papers in Class B. From *Illustrations of the British Paper Manufacture*, Queen's University, W.D. Jordan Rare Books and Special Collections, Rare Books Collection, FF TS1105 .S2.

The 1851 patent for Stones' paper outlines the manufacturing method which includes "impregnating the paper in the sizing process with ferrocyanide of potassium, iodide of potassium, and starch" (Barclay 1860, 312). Barclay, in the March 1860 *Journal of the Society of Arts,* notes that Stones endeavored to overcome the difficulties associated with other competing patent papers with his unique chemical formulation. Barclay (1860, 313) states that "on application of bleaching liquids containing chlorine, the blue compound, termed the iodine of starch, is formed, and a stain on the surface of the paper is the result. This may be completely washed away by a weak alkali, and the security is destroyed." This information is of particular interest to paper conservators, who may be considering chemical treatment of these types of patent papers. Further research is required to better understand their composition.

Colored papers

Colored papers are found in all paper classes. Class A, papers made by hand, contains 32 total samples, five of which are identified in the index as blue paper (fig. 6). However, when the research team began documenting the sample book, it was found that 11 of the handmade paper samples appeared to be blue. In the introduction to Class A handmade papers, it is noted that "writing papers are tinted blue by either smalt or ultramarine: the latter gives more intense and brilliant color, but it is not so permanent as the smalt, being more easily decomposed" (Saunders 1855).

Class B, papers made by machine, contains 54 total samples, 17 of these identified in the index as blue paper (fig. 7). The Class B machine-made papers introduction states that "the tinting of paper presents some especial difficulties, as the color must be imparted whilst the material is in the state of pulp, whereas other fabrics are dyed after the material is spun or woven. With the necessary modifications in this manner of application, the coloring matters employed are the same as used in the dying of calico" (Saunders 1855).

Class C, special papers, contains 65 total samples, 25 of which are identified as colored papers in the index. The index

Fig. 8. A selection of colored papers from Class C, including samples 93 to 112 (left), samples 127 to 131 (middle), and samples 148 to 151 (right). From *Illustrations of the British Paper Manufacture*, Queen's University, W.D. Jordan Rare Books and Special Collections, Rare Books Collection, FF TS1105 .S2.

does not identify specific colors for these samples, but they include blue, yellow, pink, purple, green, beige, and orange colors (fig. 8).

Nineteenth-century literature on papermaking describes paper color and manufacture and is a useful starting point for describing paper color, condition, and possible colorant identification. For example, Baddeley describes the difference between papers and their color:

> *Laid paper is generally of a bluish cast, which is obtained by adding smalt (the powder blue of commerce) to the pulp while in the vat. Wove paper is of two kinds, — blue wove, and yellow wove; the former of which is made by working the pulp to which smalt has been added, on a wove mould; yellow wove, on the contrary, is the pure colour of the page, considerably heightened, however by the process of bleaching. Drawing papers are always the latter, and writing papers (emphatically so called, from imperial to demy) of the first named description. (1831, 123)*

In *Paper & Paper Making, Ancient and Modern,* Herring writes that:

> *Common materials are frequently and very readily employed, through the assistance of colouring matter, which tends to conceal the imperfection. Indeed, it would be difficult to name an instance of apparent deception more forcible than that which is accomplished by the use of ultramarine. Until very recently, the fine bluish tinge given to many writing papers was derived from the admixture of that formerly expensive, but now, being prepared artificially, cheap mineral blue, the oxide of cobalt, generally termed* smalts, *which has still the advantage over the ultramarine of imparting a colour which will endure for a much longer period. One pound of ultramarine, however, going further than four of smalts, the former necessarily meets with more extended application, and where the using is rightly understood, and the materials employed, instead of being fine rags, comparative rubbish, excessively bleached, its application proves remarkably serviceable to the paper maker in concealing for a time all other irregularities, and even surpassing in appearance the best papers of the kind. (1863, 80-81)*

Herring also notes that:

> *In making writing or other papers where smalts, ultramarine, and various colours are used, considerable difference will frequently be found in the tint of the paper when the two sides are compared, in consequence of the colouring matter sinking to the lower side, by the natural subsidence of the water, or from the action of the suction boxes; and to obviate this, instead of employing the ordinary couch roll, which acts upon the upper surface of the paper, a hollow one is substituted, having a suction box within it, acted upon by an air pump, which tends in some measure to counteract the effect, justly considered objectionable. (1863, 91–92)*

In the next stage of technical examination, the T.H. Saunders Project will focus on the analysis and identification of colorants in the handmade and machine-made paper samples.

CONCLUSION

Illustrations of the British Paper Manufacture is a remarkable time capsule of mid-19th century English papers produced by T.H. Saunders & Co. and offers conservators a unique venue for ongoing research. The research team is excited to continue to share results as the T.H. Saunders Research Project unfolds.

ACKNOWLEDGMENTS

Thank you to Bader Philanthropies and the Jarislowsky Foundation for their generous gifts supporting the Queen's University Department of Art History and Art Conservation. Additional thanks to Kim Bell, Daniella Cruz, Brendan Edwards, Ken Hernden, and Jacques Talbot at the W.D. Jordan Rare Books and Special Collections.

NOTES

1. Institutions with known copies of *Illustrations of the British Paper Manufacture* include Dartford Library (UK), Harvard University (USA), Library Company of Philadelphia (USA), Library of Congress (USA), Newberry Library (USA), Queen's University (Canada), State Library of New South Wales (Australia), State Library of Victoria (Australia), St. Cuthberts Mill (UK), University of Oxford (UK), Victoria and Albert Museum (UK), and Yale University (USA) (thought to be the former NY Mercantile Library volume).
2. For additional detailed information on each of the 151 sample sheets included in the Queen's University copy of Volume 1 of *Illustrations of the British Paper Manufacture*, see the forthcoming paper "T.H. Saunders & Co. Watermarked Papers," which will be published online in the *Association Française pour l'Histoire et l'Étude du Papier et des Papeteries* (AFHEPP) *publications des journées d'étude* AFHEPP/HICSA (2021), http://www.afhepp.org/spip.php?rubrique5.

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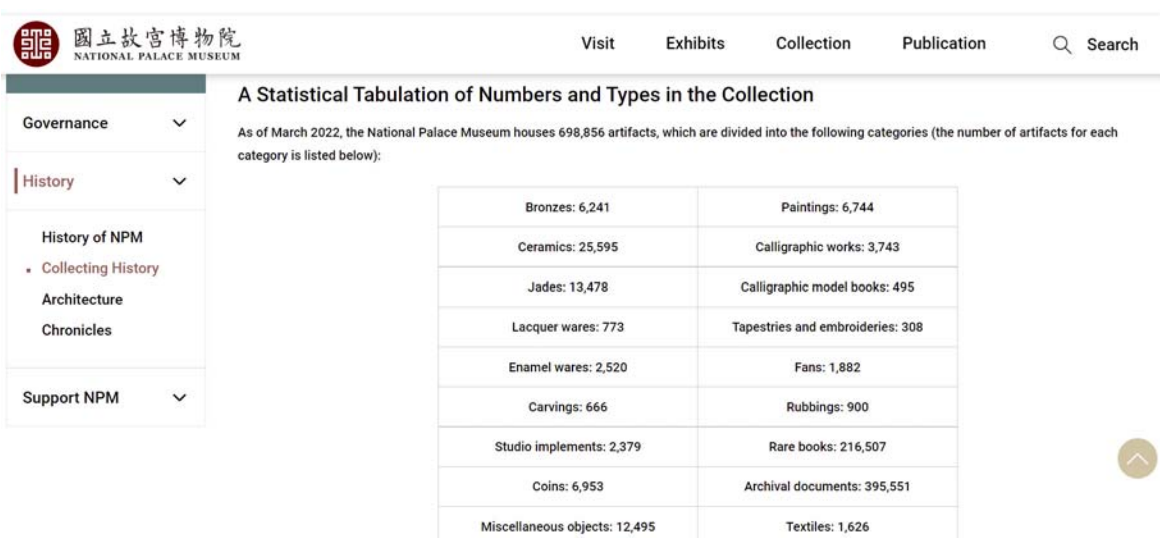
Can an Old-School Treatment Ever Catch up with the Change? A Hybrid Method for Treating and Remounting a Ming Dynasty Chinese Silk Scroll Collected in the National Palace Museum, Taipei

INTRODUCTION

The National Palace Museum, Taipei, Taiwan (NPM) is one of the wealthiest museums holding the world's richest Chinese collections. Figure 1 shows the number of objects in the Chinese collection at the NPM. This collection has over 6000 Chinese paintings and 4000 Chinese calligraphies. There are also other collections related to Chinese paintings, such as fan paintings (1882 works), rubbings (900 works), and album leaves, which bring the total to more than 13,000 Chinese artworks. These 13,000 Chinese paintings are taken care of by five Chinese paintings conservators and technicians at the NPM. Rotation of gallery exhibitions, occurring every three months, creates a tight schedule for the limited staff. Therefore, minimal treatment is often practiced while still following the AIC Code of Ethics.

THE DESCRIPTION, MOUNTING FORMAT, AND CONDITION OF *THE GARDEN LIFE*

The Garden Life (園林清課圖) is a 16th-century hanging scroll by scholarly artist Qiu Ying (仇英) (1494–1552), also known as Shifu (實父), pseudonym Shizhou (十洲) (fig. 2). Qiu Ying was a famous painter based in Suzhou province, China. He is known for his green and blue landscape style, depicting architecture, gardening, landscaping, and daily scholarly life. He is regarded as one of the Four Masters of the *Wu* School, which



A Statistical Tabulation of Numbers and Types in the Collection

As of March 2022, the National Palace Museum houses 698,856 artifacts, which are divided into the following categories (the number of artifacts for each category is listed below):

Bronzes: 6,241	Paintings: 6,744
Ceramics: 25,595	Calligraphic works: 3,743
Jades: 13,478	Calligraphic model books: 495
Lacquer wares: 773	Tapestries and embroideries: 308
Enamel wares: 2,520	Fans: 1,882
Carvings: 666	Rubbings: 900
Studio implements: 2,379	Rare books: 216,507
Coins: 6,953	Archival documents: 395,551
Miscellaneous objects: 12,495	Textiles: 1,626

Fig. 1. Lists and number of categories in the collection at the National Palace Museum, Taiwan.

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

Fig. 2. *The Garden Life,* Before treatment, overall, recto, normal light.

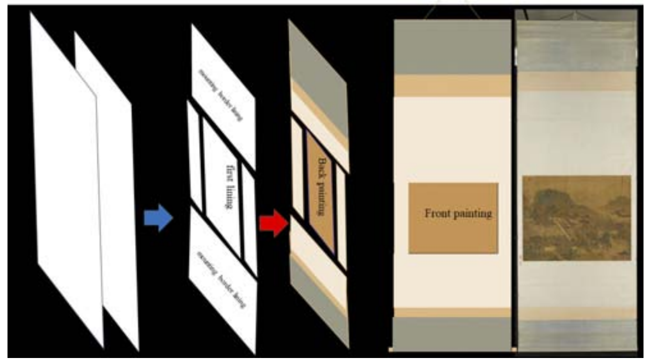


Fig. 3. Three tiers of color silk strips.

is generally characterized by literati-style ink washes. In this painting, Qiu depicts a colored landscape with mountains and a pavilion on a sheet of silk. In the "boundary drawing" (*jie hua*) style, the houses, walls, windows, doors, stairs, and roofs in *The Garden Life* are depicted with meticulous lines. There is a heavy paint layer with blue and green pigment on the mountains and trees.

The mounting structure of *The Garden Life* has a three-tiered hanging scroll format and can be divided into three tiers of colored silk strips, including a light blue upper and lower border, light orange upper and lower secondary border, and pale green upper and lower intermediary border (fig. 3). The overall measurement of the scroll is 118 cm × 326 cm, with the painting section measuring 82 cm × 106 cm.

While delamination can happen in each layer, the most common delamination is usually seen in between the last two layers of the final lining as the blue arrow indicates in figure 3. Unfortunately, this mounting support was found to be delaminating in between the painting and its first lining, indicated by the red arrow in figure 3. The severe delamination between the silk painting and the first lining meant the action of rolling and unrolling the scroll would jeopardize its fragile condition.

The painting silk (the primary support) of *The Garden Life* was brittle and detached from the lining. There were many creases and splits across the center of the painting (figs. 4, 5). There were many silk losses and cracks due to the sharp creases (fig. 6). The first lining paper was too light in color, making the losses in the splits more visually pronounced (fig. 7).

The "cover silk" that protects the rolled scroll of this painting was found to be heavily damaged; however, the mounting materials appeared flat and flexible. A record of the previous remounting was not found at the NPM; however, there was a record from 2005 of an old minor remedial treatment of the silk borders. Figure 8 shows the old repairs at the upper border silk under transmitted light. Based on Sun-Hsin's experience

Fig. 4. Creases, and splits, before treatment, detailed, recto, raking light.

Fig. 5. Creases and splits, before treatment, detailed, recto, raking light.

at NPM, these old mounting materials, including the border silk, are estimated to be from the late Ming to early Qing dynasty. Due to the poor condition of the painting, it was not recommended for display, and treatment was proposed.

CHALLENGES AND DISCUSSIONS

This project was a challenge not only because of the delicate and meticulous nature of the painting but also because the original silk borders would not be replaced but rather treated. Four major challenges were faced when completing this project.

Realigning splits

Due to the poor condition with the splitting in *The Garden Life* as stated above, it was necessary to replace the first lining paper with a stronger one. Water is usually introduced in limited amounts during lining removal to reduce the risk to water-sensitive binders and heavily painted mineral pigments,

Fig. 6. Creases and splits, before treatment, detailed, recto, raking light.

Fig. 7. Splits in the sky, before treatment, detailed, recto, raking light.

such as the green, blue, and white pigments in *The Garden Life*. However, the splits across the painting needed to be realigned. More water was required to realign and join split areas of the painting silk where the sky was depicted by using the "water-floating technique." This needed to be done before the surface of the painting could be faced for protection in preparation for the next steps of treatment. However, the splits in the more heavily painted lower areas were not realigned to reduce the risk of distorting brushstrokes. Therefore, the painting silk in these areas was left alone as well and not realigned to avoid distorting the painting silk.

Preserving the mounting format

The mounting structure for this hanging scroll can be divided into three colored tiers of border silks. The three parts of the mounting components were individually separated and treated and then joined back together to keep as much of the original mounting format as possible.

Retaining old material

An important goal of this treatment was to retain the old materials, including the original border silks on the recto and the lining layers of *xuan* paper. Figure 9 shows the four silk borders surrounding the painting, which were separated for treatment. After disassembling the four silk borders,

Fig. 8. Old repairs appeared under transmitted light.

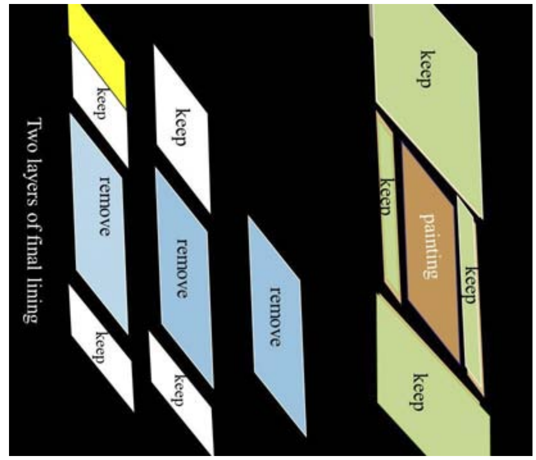


Fig. 9. Hanging scroll structure and decision to remove each mounting component.

there were five components: four sides of the silk border and the painting. The four silk borders, depicted in green in figure 9, were lined with two additional layers, depicted in white. These layers of linings were not removed from the silk borders, and only the "cover silk" depicted in yellow was replaced due to severe tears. In contrast, three layers of lining on the back of the painting, depicted in blue, were removed and retained separately. A question might be raised: why retain the old paper linings? Firstly, the first and final linings of the painting were *xuan* paper. These lining papers used for supporting the artwork had been adhered to the artwork since the last conservation/mounting campaign; in this project, the old mounting material was at least 300 years old, and therefore, it can be considered part of the artwork. Secondly, old paper-making techniques and materials are considered of better quality than modern ones due to source material limitations nowadays, according to the senior conservator of Chinese paintings in the NPM.

Controlling contraction rate

When each lining layer in the Chinese scroll was separated, at least three layers of linings were seen (see fig. 3). Traditionally, each component of the scroll, the painting, and the four pieces of the silk borders are first lined individually. Each lined border is then joined to the perimeter of the lined painting, forming one large piece. Two or three layers of paper are then laminated together with paste to form the "final lining," a sheet equivalent in size to the joined painting and silk borders. Two layers of "final lining" were used to line the joined painting and silk borders of *The Garden Life*. Each layer requires a different thickness of the paste. As Chinese scrolls have multiple components and layers, controlling the expanding and contraction rate of the lining is essential when the scroll is wet treated, paste mounted, and placed on the drying board.

TREATMENT STEPS

Pigment solubility test and consolidation

After the painting was carefully examined and documented, it was found that the red seals on the silk borders were sensitive to water (fig. 10). Fish gelatin in water (1%–2%) was applied to consolidate the seals. The rest of the paint layers were found to be mostly stable. However, the green, brown, and white areas were consolidated with 1% fish gelatin in water to further stabilize them for the next washing step. The consolidation process was repeated until the ink, paint, and seals were tested to be stable.

Disassembling the painting

The upper and lower rods of this scroll were first removed (fig. 11). The scroll was then divided into five parts: the upper, lower, and two sides of the silk borders and the painting sections. The joins between the painting and the borders have adhered with a paste, so the old material from the orders was easily peeled away from the painting by introducing a limited amount of water (figs. 12, 13).

Fig. 10. Testing the stability of the red seal at the painting and border.

Preparing new paper for the first lining

Because the old *xuan* paper used for the first lining (depicted in blue in figure 9) no longer supported the painting, new replacement paper needed to be prepared before the washing and lining removal process. Toning the lining paper to give the painting more saturation from the back is standard when lining old silk paintings. The toned lining paper applied to the painting can also reduce the light transmitted through the support, which is an open-weave silk. The toned paper is also applied to reduce the distraction of tiny splits and losses.

Fig. 12. Separating the silk borders.

It is critical to tone the paper that will be used for the first lining before washing the painting and removing its old linings, as the color of the painting cannot be seen clearly when it is wet and facing down mid-treatment. However, it can also be hard to achieve the correct tone for the new lining before washing the painting, as the tone of the painting may lighten after the washing process. Besides color, the type of paper used for the first lining and its weight are also critical because it directly contacts the back of the painting. To better adhere to the painting and maintain flexibility, one must consider the type, weight, thickness, and color of the lining paper. Chinese paintings are usually lined with short-fibered *xuan* paper. However, this is not always the case with NPM collections. According to the museum's documentary records, use of long-fibered *kozo* paper for the first lining is sometimes found in NPM's Chinese collections. Long-fibered *kozo* paper, *mino* in Japanese, was selected for the lining of this painting as it is thin, strong, and light weighted, and thus better supports splits in the painting. In preparation for lining, it was toned beige using a brush (figs. 14, 15).

Fig. 11. Bottom roller revealing.

Fig. 13. Separating the silk borders.

Fig. 14. Coloring Japanese mino paper.

Dry and wet cleaning the painting surface

Accretion on the painting, confirmed to be dirt, was removed prior to wet cleaning. The NPM is fortunate to have an oversized, custom suction table for washing, as regular-sized suction tables are often not big enough for most Chinese paintings. Warm water was introduced to the back of the painting, and the old reinforcing strips were removed (fig. 16). The recto of the painting was covered with a Rayon sheet and sprayed with water. The washing process was repeated twice, and the collected water from the suction table turned clear by the end of the process (fig. 17). No chemical solution was used.

Individual treatment of the mounting components

The four sides of the silk border that had been detached from the painting were individually cleaned (fig. 18). A label with the title was carefully removed from the "cover silk" and replaced with the new lining. The "cover silk" on the back of the upper border was replaced with a new one. The upper and lower final lining paper was partially removed at the top and bottom. As the "pocket paper" at the top and bottom of the scroll were no longer functional, it was replaced with new paper (fig. 19). This pocket paper is used for the installation

Fig. 15. Coloring Chinese xuan paper.

Fig. 16. Washing the silk painting.

of the wood dowels. All mounting components were put on the drying wall with the verso facing the wall. Figure 20 shows the lower mounting on the left and the upper mounting in the middle, with the title label and paper records that were pasted on; the painting is shown on the right.

Facing

The facing process protects the surface of the painting during the lining removal process. Methylcellulose (MC) was used to apply the facing tissues; a thicker solution (2.5%) was prepared for facing the sky area and a thinner solution (2%) for heavily pigmented areas. The MC was applied to pre-cut pieces of acid-free, machine-made tissue; these were applied to the surface of the painting, with each sheet overlapping roughly three to five centimeters. A single facing layer was applied directly to the painting, followed by a sheet of kozo paper and a sheet of xuan paper (fig. 21).

Removal of linings

Once the faced painting dried in the air, it was slightly dampened and placed face-down. The perimeter of the faced

Fig. 17. Collected washed water: first wash on the left and second wash on the right.

Fig. 18. Washing the silk borders.

Fig. 19. Attaching cover silk.

Fig. 20. All components on the drying wall.

Fig. 21. Pasting facing paper onto the surface of the silk painting.

painting was pasted and fixed onto the table's surface, which is equipped with transmitted light. The layers of linings were gently and carefully removed with tweezers and fingers. Minimal water was applied each time on the paper that was being removed. Raking and transmitted light were used to determine the layers while removing the linings. There are usually three layers of *xuan* paper applied on the back. Each layer was removed individually (figs. 22–25).

Infilling to losses

Silk for infilling that matches the painting is not always easy to acquire because there can be many types of silk used for Chinese paintings. The NPM has tried to acquire as many types of painting silk as possible, but none of them were a perfect match for *The Garden Life*. The most similar silk, with threads as close to the original as possible, was sent to the Institute of Nuclear Energy (INER), Taiwan, to deteriorate it artificially.[1] For infilling, the artificially-aged silk was trimmed slightly bigger than the loss, with the overlapping areas securing the losses (fig. 26).

Fig. 22. Old paper strips removal.

Fig. 23. Lining removal.

Fig. 24. First lining removal.

Fig. 25. First lining removal.

Fig. 26. Infilling the losses with the aged silk.

First and second lining

Traditional Chinese pigment was mixed with a gelatin solution to tone the *mino* (fig. 27) and *xuan* (fig. 28) papers with a brush. Fresh starch paste was applied on the *mino* paper, which was then adhered to the back of the painting. After the first lining, the facing paper was then removed (fig. 29).

Reinforcing creases

Strips of *mino* paper were pre-trimmed and pasted onto the areas showing creases and weaker areas. The areas that needed reinforcing strips were marked with a pencil. Raking and transmitted light were used during this process.

Inpainting

The goal of inpainting was only to reduce the distraction of the missing areas but not to repaint the missing images (figs. 30, 31).

Assembling

The major challenge of this treatment was that the dimensions of the painting components before and after treatment

Fig. 27. Lining with mino paper.

Fig. 28. Second lining with xuan paper.

could differ due to expansion and contraction during the washing and drying process. This concern was discussed ahead of the treatment.

The silk painting was dried on the drying board, and the dimensions were measured. The upper and lower border silks were dampened, smoothed out, and allowed to dry in the air. As the painting would shrink slightly once it dried over time, the border silks were shifted to the drying board while slightly larger than the painting; they were then allowed to keep shrinking on the drying board. The expansion rate was carefully controlled to match the dimension of each component. All dry components were adhered together with a fresh, thick paste (fig. 32).

Final lining and flattening on the drying board

Traditionally the final lining requires two layers of *xuan* paper that are pre-laminated and allowed to air dry. The paper linings of upper and lower border silk were kept; only the painting was relined with a sheet of toned *xuan* paper and Pineapple *xuan* paper. This pineapple *xuan* paper[2] is textured, thin, and smooth as traditional *xuan* paper with strong fibers comparable to *kozo*. The original lining paper of the upper

Fig. 29. Removing the facing paper after the first lining.

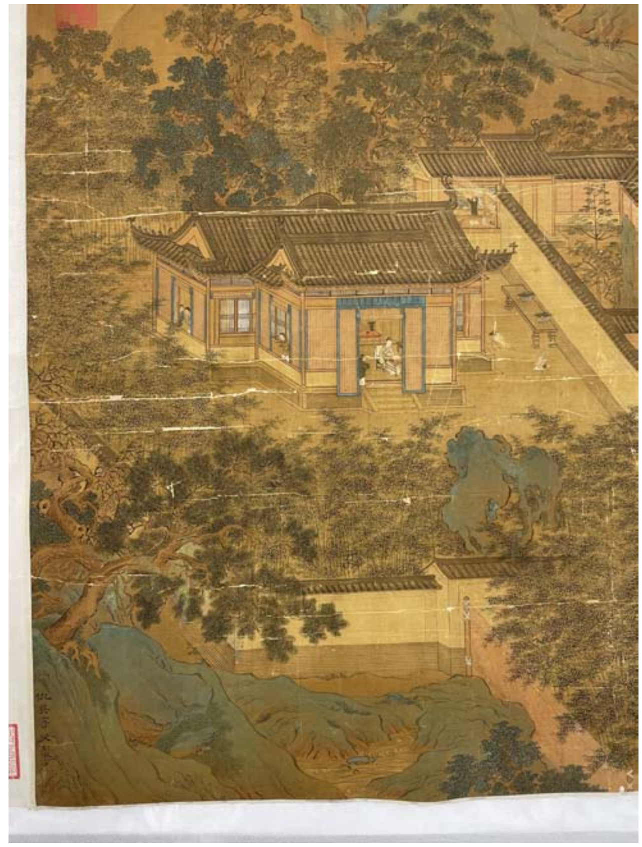


Fig. 30. Before inpainting, detailed.

Fig. 31. After inpainting, detailed.

Fig. 32. Rejoined the border silk.

Fig. 34. After final lining on the drying wall.

and lower borders, two sheets laminated, was first trimmed staggered, facing down, for the later lining paper to join. The pre-laminated sheets were applied onto the back of the painting section and smoothed to secure them (fig. 33). The whole laminated painting was air dried. The painting section was then water sprayed, fixed to the drying border, and faced up. The mounted painting was transferred to the studio's drying wall to save space. The remounted painting was burnished on the back with wax and stone after being on the wall for at least six months (fig. 34). The extended strips were trimmed off, and the upper roll, lower dowel, knobs, rings, hanging, and tying cords were installed to complete the project.

CONCLUSION

Traditionally, remounting a scroll with Chinese methods seemed to be the only path to treat a Chinese painting because a local treatment seemed unfeasible and impractical due to the numerous laminated layers and water-soluble paste on the back of Chinese paintings. Therefore, conserving a Chinese scroll almost always meant remounting it. Oder mounting elements tended to be discarded during remounting because of their role as "backstage contributors." The lining layers were considered less important because they were not displayed but rather hidden against the wall. Moreover, the silk borders were usually replaced with new ones because they were considered secondary to the painting. In the past, the mounting styles were even changed by the tastes of the curators or collectors because these mounting materials were not considered part of the artwork. Now, rather than discarding older elements, accessories for mounting a Chinese scroll are viewed as precious as the artwork itself because they can be studied to document the historical techniques and methods of the period; therefore, new treatments attempt to save as many original mounting materials as possible. In the last decade, minor remedial treatments of Chinese scrolls in both the US and China have gained much attention and been promoted as having as good an outcome as complete remounting. When the principle of minimal intervention is applied to Asian scrolls, the old mounting elements need to be kept as much as possible.

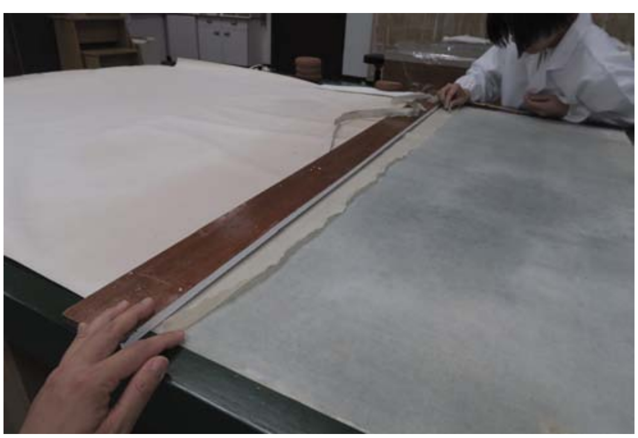


Fig. 33. Final lining.

Asian painting conservators nowadays are trying to reveal each artwork's "authentic" mounting style. Judgments on the low importance of retaining these materials and the simple fact that it is easier to replace an older mount with a newer one contributed justifications for complete remounting. In other words, it is more complicated to locally treat Chinese paintings due to the complexity of aged and fragile multilayers of mounting; it is challenging to give the treated parts of the scroll the same flexibility and thickness as the untreated parts, which is a task that requires a high level of skill. Nevertheless, a remounting process is also not without challenge, as it can be considered an aggressive approach given the amount of water introduced into the object.

Fig. 35. After treatment, overall, recto, raking light.

The more minimally interventive treatment approach for *The Garden Life* did not reduce treatment time in comparison to traditional remounting despite the combination of the conservators' proficient mounting skills and innovative methods. However, this approach reduced the potential risk of harming the artwork and allowed much of the old silk borders to be saved, reused, and safely put back on the scroll to maintain its authenticity (fig. 35).

This project was made possible through the cooperation of conservators from the National Palace Museum in Taipei and the Cleveland Museum of Art. This paper demonstrates the innovative techniques and thought process behind this treatment that resulted in the older elements being saved and safely reused. Keeping these mounting materials facilitates the study of the mounting materials, including their manufacturing and the period's aesthetics.

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NOTES

1. Located in Longtan District, Taoyuan City. The gamma ray was used with 70 K Gray for about 335 hours to deteriorate the silk fill. The absorbed dose is the amount of energy deposited per unit of mass. Most often this is measured in grays (Gy).
2. Pineapple fiber mixed with bamboo fiber; handmade in FENKO company, Taiwan.

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Professional Identities in Library and Archives Conservation

PANELISTS

Ellen Cunningham-Kruppa, Associate Director for Preservation and Conservation, Harry Ransom Center, University of Texas at Austin
Justin P. Johnson, Senior Conservator, Books and Paper, University of Washington Libraries
Christine McCarthy, Director of Preservation and Conservation Services, Yale University Library
Karissa Muratore, Conservation Resident, Northwestern University Libraries

INTRODUCTION

In a one-hour session, four panelists presented their personal reflections and experiences that developed their professional identity in the field of library and archives conservation. A series of short self-introductions were followed by a panel discussion and Q&A session with the audience.

Over the course of roughly 50 years, the specialization of library and archives conservation has matured while withstanding a significant series of shifts that have shaped the role of the modern-day conservator.

The evolution of training and educational models—from apprenticeship, to librarianship, to art conservation programs—has imbued the field with an amalgam of perspectives, if also resulting in ambiguity. As such, the needs of the library have called for a reprioritization of the skills offered by conservators that reaches beyond the traditional model of a technically focused practitioner.

Simultaneously, the term "conservator" itself conjures debate about professional identity, institutional hierarchy, and personal point of view. "Conservator" was initially used by the organizers as a blanket term to frame this discussion, knowing that it may not clearly define or be fully applicable to the role of each participant in this panel. We came to understand that "conservator" did not reflect the identity of some of our panelists and that this rejection of the term and identity was a distinction at the core of this discussion. We instead chose to use "conservation professional" as a catch-all term to refer more broadly to a range of roles that serve the profession. While we each have a very specific understanding of and relationship to descriptors such as conservator, technician, librarian, administrator, etc., we have yet to come to terms with these labels in a consistent way, and many find themselves straddled between these various roles. As the field of library and archives conservation continues to evolve, so too does this language used to describe our place within it.

Today's conservators have many other "hats" to wear—scientist, photographer, advocate, scholar, etc.—that reach even further beyond more traditional roles. How do library and archives conservation professionals today define their own professional identities and values? What forces drive their impact on the collections they serve?

DISCUSSION

With over 35 years in the field, Ellen Cunningham-Kruppa described her roles as an archivist, an administrator of a large ARL preservation program, a preservation and conservation graduate education program director, a teacher, a doctoral student, and currently an Associate Director of the Harry Ransom Center (HRC). In this current role, Ellen wears two hats. First, as an Associate Director, where she is a member of a leadership team involved in every aspect of operations and strategic planning. She thinks about every operation at the HRC and needs to understand how each impacts the others. The second part of her job is as the administrator of Preservation and Conservation Division operations, which includes oversight for six conservators and four conservation technicians. Ellen described her past experience as a preservation officer of general collections and reflected on how her early experience prepared her to take on new challenges,

This open discussion took place on May 17, during the AIC 50th Annual Meeting, May 13–18, in Los Angeles, California. The moderators organized and led the discussion and recorded notes. Readers are reminded that the moderators do not necessarily endorse all the comments recorded, and that although every effort was made to record proceedings accurately, further evaluation or research is advised before putting treatment observations into practice.

such as overseeing the assessment and treatment of rare and unique collections for large-scale exhibits. The collections at the HRC are broad, consisting of books and archival materials as well as paintings, objects, photographs, motion picture film, and fine art on paper. Most recently Ellen has led planning for the move of collections for an upcoming building renovation project and has been working on the pre-planning and preparations needed to make this project successful. This is a very new experience for her in which she is learning about this process. Her role has also expanded to serve the collection treatment needs of primary cultural institutions at the University.

Justin Johnson introduced himself as representing the overseas trained cohort of conservators. He attended West Dean College in the United Kingdom and earned an MA degree through the University of Sussex before returning to the US to begin his career. Justin has worked for private and public institutions, a for-profit regional center, as well as private clients. He identifies as a West Coast conservator, having lived and worked in this region exclusively for his entire life.

Christine McCarthy has been the Director of Preservation & Conservation Services for the Yale University Library for the past five years. Nine years prior to that she served as the library's Chief Conservator, overseeing both conservation and exhibits, additionally taking general collections conservation under her leadership during this term. The Yale Library has a full gamut of collection material. Preservation & Conservation has 25 staff members overall, with activities including conservation, commercial binding, exhibitions, loans, teaching, and facilitating material culture research. Newer functions include digital preservation, such as software emulation. Yale also has a fairly robust digital reformatting program founded in the brittle books programs of the 1980s and 1990s, which now includes scanning digitization as well as audiovisual materials. Christine received her MLIS at the University of Texas at Austin and a Certificate of Advanced Study in Conservation. She followed a solid library and archives trajectory from the beginning, with her first library job at Brandeis University in 1992, and has since only worked in academic research libraries, with 30 years overall and 22 of those in postgraduate positions. Christine transitioned early in her career from freelance illustration and graphic design, with a background focused on visual interpretation, to working as a bench conservator, and then on to managerial, administrative roles, which is her primary focus at Yale.

Karissa Muratore is completing a two-year term as the Conservation Resident for Northwestern University Libraries. In 2020 she graduated from the Winterthur University of Delaware Program in Art Conservation (WUDPAC) and considers herself an emerging conservator, standing on the shoulders of those who came before her. She came to conservation later in her studies and took a while to find her entry point. Karissa was actively dissuaded from entering the field. After exploring alternatives she decided she couldn't see herself doing anything else, so she went all in. She got a second undergraduate degree in art conservation before moving onto WUDPAC. She considers the timing fortunate as she was one of the first classes of students to receive training through the Mellon-funded Library and Archives Conservation Education (LACE) program. LACE offered a wonderful model for working together with other colleagues, creating an invaluable support network early on.

Jen Hunt Johnson presented questions for the panel:

How would you describe, or what has shaped your professional identity? How has your training program influenced this identity or not?

The educational programs of each panelist include:

Ellen – Columbia University School of Library Service Conservation Education Programs
Justin – West Dean College of Arts and Conservation
Christine – The University of Texas at Austin Preservation and Conservation Education Program
Karissa – Winterthur/University of Delaware Program in Art Conservation (WUDPAC) under the LACE (Library and Archives Conservation Education) consortium, funded by the Mellon Foundation.

The panelists each came to their programs from unique perspectives. Karissa began her studies thinking she would learn how to acquire all of the bench skills needed to do treatment. Instead she discovered that her program taught her how to *learn*. She learned much more than benchwork. She described this as a discovery process. Realizing that she hadn't been trained for benchwork alone, she was not initially sure where she fit into the career. *"What I thought I was supposed to do [bench conservation treatment] is [now] becoming a technician job … being a conservator is more of an all-inclusive position in the lab … it's great, it just took me a while to realize it was happening."*

Christine's training capitalized on her intentional trajectory to work in libraries. She deliberately chose an MLIS (Masters in Library and Information Science) educational path. *"The context of the library is what I was in love with. I chose that path specifically, and wanted to get the library degree to get a professional position, which is hard to get without it. I still draw on the five years I spent as a technician, honing and practicing skills, knowing a conservation program would be far more than benchwork."*

In terms of identity, Justin considers himself a bench conservator. The program at West Dean had a narrow focus of developing hand skills at the bench with not a lot of peripheral skills like administration. *"We studied the book as an artifact, and other values were not discussed in great detail. I developed a very narrow decision-making process. I am most comfortable as a bench conservator and have resisted anything to pull me away from that, though it seems like an unavoidable transition."*

For Ellen, a commitment to providing access to information was her draw to libraries early on. Education became a strong focus throughout her career from her own beginnings in preservation administration at Columbia University, through directing the UT Austin School of Information educational certificate in library and archives conservation and preservation administration, through working with Chela Metzger and the art conservation education programs to help get their Library and Archives programs up and running, and most recently her research and writing about the early professionalization of the field and Paul Banks' role in founding the Columbia program (Cunningham-Kruppa 2019). She has *"thought a lot about what was the trajectory of our field into higher education, and the implications of moving into higher ed., and what is disciplinarity? Are we a LIS specialization or are we an art conservation specialization? I think we are in the right place now."*

Question 2: Did your pre-professional expectations of the field change post-training?

Expectations either changed or were clarified for all panelists following their educational programs. Karissa felt her expectations were definitely changed as she had different ideas of what her program would prepare her for after graduation. As noted earlier, she went into school intending to be a book conservator but now feels less comfortable with that label and more comfortable with the title "library and archives conservator." *"I think the distinction lies in the fact that I feel like I know a little about many things (e.g., materials, treatments, collection-care, preventive conservation, photography, research, data-management, writing, presenting, outreach, fundraising, etc.) … versus being a specialist in any one area."* Karissa sees this as having given her the preparation to contribute to the development of the field as it continues to grow.

Early in Christine's training she wondered if she had made the right choice. She felt overwhelmed by the range of roles she felt she needed to know to be successful in a library environment. Her third-year internship with Jan Paris helped her to focus on where she fit by seeing how Jan made things work in the reality of a small lab. The shift from theoretical knowledge to working within the realities on the ground was what changed most for Christine.

Having grown up isolated from a conservation presence, Justin had no expectations when beginning his education at West Dean. He thought about becoming a librarian but decided that wasn't for him. He went into conservation without having ever met a conservator. Justin began with a lot of self-study in repairing books pre-program, and West Dean agreed to take him with this limited experience. During his time at West Dean he participated in a number of site visits to conservation labs, but none were representative of the environment he ended up in. *"[I] still don't know what to expect. It is always changing."*

Ellen went into a program with altruistic ideas but after graduation landed her first job *"as head of the fifth largest (ARL) research library in the US, starting a new preservation program, 27 years old, 13 people reporting to me, all of whom are older than me, and trying to pretend like I knew what the hell I was doing."* She describes how different her job was from learning about preservation management in class. Ellen also noted her preference to use the term *"educational program"* to describe formal study in conservation, *"not training program, we are all knowledge workers."*

Question 3: How do you feel your personal identity intersects with being a conservation professional? For example, one might take an unpaid position for the experience and feel taken for granted, or one might feel fulfilled or informed by doing community work, volunteer service or other personal pursuits.

The panel was evenly split in their responses to this question. Karissa and Christine spoke of experiencing their work as all consuming, with sacrifices being made in the form of excessive student loans, relocation away from families, feeling the need to postpone personal goals like home ownership, or pursuit of personal interests to prioritize work. Each was clear to state that the career has been a good fit for them personally, and neither expressed regrets, but acknowledged that finding balance between personal and professional identity is an ongoing process.

As Christine progressed in her career she learned that conservation is a marathon, not a sprint. *"You have to take it down a notch and figure out how to continue to be effective, without allowing every loss, every setback to take its toll, and to not feel like you have to make the difference up when, say, an institution can't afford to do something or is not willing to do something. This has been the hardest piece for me in separating myself and work."*

On a positive note, Karissa spoke about the support she received from numerous mentors in the field, in particular the relationship she had with Vicki Cassman whom she met prior to beginning her studies at WUDPAC.

> *"She was the first person to say 'yes' to me, which she followed up with helpful advice and continued support. Not only did she shape my foundational concepts of what conservation is but also what kind of conservator I want to be. The joy and love for the work and her students was so inspiring, it was literally life changing for me. I would not be where I am without her and all the wonderful mentors I have had since. Thinking about it now, I believe it is the people I have been lucky to meet along the way that have most significantly shaped my identity as a conservator. Everyone in the field has been amazingly supportive, but yes it has been all consuming and it is taking its toll, and I'm not going to lie about that."*

Justin and Ellen acknowledged privileges in their lives including financial and family support they have received that made their careers possible. In Justin's words,

> *"I am extremely lucky to not have gone through the slog as a pre-program intern, and fit through the very narrow funnel to become a*

> *conservator in this country. That is not the experience that I had, but I have been witness to it, and that has shaped my own perspective and identity and I don't know how much of that was luck as much as it was privilege that I wasn't able to recognize until later in life. I want to acknowledge that. Much of what has gotten me to where I am today is as a result of privilege."*

Ellen echoed Justin's comments and acknowledged the support she received from her family throughout her career, as well as acknowledging she works at a privileged institution, alongside fabulous conservators and technicians who are masters of their work. She also spoke about how her relationships in the field have shaped her,

> *"I have so many friends in this field including my best friend. How many professions can say that about their colleagues? We are collegial, we are collaborative, we care for each other, we give information to each other, and we support each other. So that is also a part of my identity and what I try to do as a mentor—to bring people in, have them feel well supported, loved, and confident that their career is going to be brilliant."*

Question 4: Today's conservators have many "hats" to wear: technician, project manager, scientist, photographer, advocate, scholar, historian, manager/administrator, etc. Do you feel like you need to master other skills or crafts in order for you to be successful in your role? And how?

All of the panelists agreed that constant learning was a critical part of the profession, particularly to develop skill sets that reach beyond conservation work. Skills in the areas of administrative management, marketing, working with donors, public speaking, persuasive communication (both written and oral), writing grants, librarianship, and project management were among those named.

Ellen spoke about her leadership role at the HRC and her need to understand as much as possible every aspect of what happens within the organization, especially how programs work together to move the organization forward.

Justin has had to learn how to communicate effectively with his librarian colleagues, as librarianship was not a part of his formal education. Librarians have *"their own language and speak in acronyms. Often after many years of working with them I still have to stop them in the middle of a meeting and ask them what they're talking about."*

Christine emphasized the importance of understanding conversations and being able to facilitate on behalf of her team. *"I need to understand just enough to be able to advocate for them, bring back and forth different understandings and things. I think there is tremendous pressure in conservation that we either close in and stay focused on a narrow kind of universe or we have to try to embrace expanding out and really understanding the work of everyone around us."*

As someone just starting her career, Karissa noted the pressure she has felt to learn all of the skills she may need. In the past few years she has begun to reach out to other professionals (both within the field and adjacent fields, e.g., librarians, scientists, data analysts, etc.) with questions, realizing she does not need to be proficient in everything. *"[I] have to be aware and proactive in going out and getting answers, but I do feel that there's a lot to know and I'm never going to catch up."*

AUDIENCE QUESTIONS

Question 5 from the session chat: What career paths are available to bench-trained conservators who can't afford an advanced degree?

Ellen mentioned that many positions will consider other relevant training and experience aside from a specific advanced degree. She advised bench-trained conservators not to be discouraged from applying for positions when the job posting allows.

Christine went further and suggested looking at lots of different institutional contexts for positions as requirements can differ significantly.

> *"Some places like my institution have strict and hierarchical systems for how those positions are graded … that can create a real tension about who is a conservator and who is a technician. Our techs do amazing work, they do conservation work, so our system doesn't really work to provide the full spectrum of opportunities, but that can vary and one has to be aggressive in finding those opportunities until bigger institutions catch up and figure out how to make it work."*

Questions 6 and 7 from a live audience member: "I have two very different questions, one has to do with identity in terms of the collections that you work with. Do you ever work with things that you don't feel even slightly connected to, in terms of your background, your family, socioeconomics? And then the other question is more like, I'm hearing that some of you have tried to pick up a lot of different skills because it's really what's been necessitated, and others have tried to really focus more in on your skillset, and I was wondering how that was reflected in your specific workplaces like how is work delegated when you're not comfortable … doing certain things, how is that picked up by other staff, or is that entire project dropped by your department?"

Three of the four panelists responded and discussed their strategies for working with materials that fall outside of their technical expertise or cultural familiarity. They each acknowledged the limitations of their training in comparison to the extensive collections they encounter in research library settings and recognize they can't know everything they might need to ethically engage in treatment for certain materials.

Christine described how her institution is fortunate enough to have money for outsourcing and lab space where she can bring in specialists to work onsite when needed. She cited a collection of Tibetan thangka materials as an example: *"[you] go out and see who that expert is for collections and bring them in, because none of us have that background or connection either culturally or spiritually to those materials. You can't do it all, you can't know it all. It's impossible."*

Even after aggressively pursuing experience in treating materials from all over the world during her training, Karissa realized that she couldn't know it all, and may not even know enough to ask the right questions. Her strategy in this situation is to lean on her preventive conservation skills to offer the object protection until it can get the appropriate care. *"Sometimes the best you can do is not touch it."*

Working in a research library environment, Justin has frequently had to care for things to which he didn't have a connection. He discussed his limited experience with paper conservation and how he has negotiated what he is willing to do in terms of treatment for works on paper. He continues to learn and has developed a greater spectrum of approaches in order to provide more options for treatment, *"While I won't necessarily do what you have in mind, I can come up with a few options that can at least hold it over until the right person comes along."* Justin also noted that with a greater acquisition of works on paper, his institution was able to hire a paper conservator to focus on these materials.

Question 8 from the session chat: What type of continuing education have you found most useful to you, and what kind of mid-career learning opportunities do you think are lacking?

Two of the panelists responded to this question, commenting on the limitations of time and money to make use of the available opportunities out there.

Christine sees AIC providing many great opportunities from beginner to advanced level skills, but as an administrator struggles to find the time and funds for people to take advantage of them. *"There are always more opportunities than we feel we have the money, the time, or the means to do, so that's an important thing to think about."*

Ellen recommended asking about continuing education support when applying for positions and to make use of that as a bargaining chip. In her recent experience, learning effective communication strategies has been most helpful for her to communicate with a variety of audiences. *"We've got to translate what we do, get away from our lingo, talk to people in real terms about the meaning of cultural records to their lives, to their enjoyment, and research. Communicating effectively with provosts and people like that, you have to make a case, the elevator speeches [are critical]."*

CONCLUSIONS

Topics that emerged from this small panel touched upon broad themes in library and archives conservation. Even here, the importance of professional identity was apparent. The panel was originally conceived to focus solely on conservation and conservators, but two of the panelists clearly indicated they do not identify as conservators, even though their roles have great impact on conservation and the conservators they serve to mentor. This distinction indicates the weight placed on identifying as a "conservator" with respect given to the technical expertise required for hands-on treatment. Library and archives conservation, perhaps more than other conservation specialties, navigates a conglomeration of professional expertise including librarianship, archival methodology, administration, and management, etc., to meet the needs of research institutions. Defining one's identity within this environment is personally significant but also crucial to accurately communicating one's role within the institution.

Despite their different paths and professional experiences, each of the panelists expressed deeply personal considerations in making the decision to pursue their careers. Panelists were strongly driven to follow their career path, in spite of discouragement in some cases, recognizing conservation, preservation, and librarianship respectively, to fit their personal skills and attributes. For these panelists remuneration in conservation is as much personal as it is practical.

Panelists spoke about deeply rooted personal connections and relationships they have developed throughout their careers, from impactful early career mentors to their own service in mentorship roles, as well as the willingness of colleagues across the field to offer support to one another. Respect for teammates and colleagues within their institutions was of significant importance to success. The strength of these relationships was identified as unique to the conservation field.

The impact of privilege was acknowledged in panelists' ability to pursue education and career opportunities. Two panelists specifically spoke about costs, both personal and financial, in pursuit of their conservation careers.

The following areas for further exploration may indicate where the next evolutions in the field arise:

Issues regarding equity were raised in a couple of different ways, the most familiar being limited access to the field and the cost of pursuing the required education and credentials. This is a concern most professionals are well aware of, though we are only at the very beginning of creating meaningful actions for change.

Inequity of institutional hierarchies between "professional" and "nonprofessional" roles was noted, including limitations this may put on the valuation of technician roles in particular. Many emphasized the exceptional talent of technicians, yet limited opportunities for career growth exist. Like many fields, management and administrative roles provide the predominant path to advancement, though the skills needed for success in these roles are often different from the skills that make a successful bench technician. Communication skills, for example, were considered vital among the panelists, particularly to managerial positions, but these skills were in no way exclusive to these roles. The need to negotiate treatment and collaborate with colleagues having unique professional cultures (librarians, archivists, curators) affects conservation professionals across all levels. This can be a challenge for those conservators who find their fulfillment and professional identity in bench-focused roles. Rapidly shifting education models don't always prepare students for the realities of the work they will be asked to prioritize as they progress in their careers. Reexamining the hierarchy of limited position classifications, particularly in large academic institutions, was noted as a possible next step to create more openness and allow for differences in education trajectories.

Each of the panelists approached their path uniquely, utilizing their own personal strengths. This sits at the heart of the extent of conservation identities and highlights the diverse expertise each person brings to the field. By embracing our distinctive qualities and capitalizing on the fact that we are a sharing and generous cohort, we create a field that is stronger, more nimble, and adaptable to change in new technologies or shifts in our field, but also in how we define ourselves.

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BONG HitS 4 JESUS: Conserving a Controversy

INTRODUCTION

Morse v. Frederick

The story of the BONG HitS 4 JESUS banner begins in Juneau, Alaska in 2002 with the Salt Lake City Winter Olympic Relay. On January 24, as part of a school-sponsored event, the Juneau Douglas High School (JDHS) let the students out early so they could be part of the Olympic Torch Relay. A student named Joseph Frederick, along with 12 other students, decided he wanted to make a statement. The students acquired a large sheet of butcher paper from the school cafeteria and a roll of duct tape. Using the tape, they wrote out the phrase "BONG HiTS 4 JESUS" on the butcher paper. Joe Frederick later claimed he had seen the phrase on the side of a snowboard (figs. 1 and 2).

Later that day, as the students were standing along the side of the street waiting for the torch and media to come down the street, Joe Frederick and the 12 other students held up the banner along the sidewalk with the hope of getting some media attention. Deborah Morse, principal of JDHS, was standing across the street. She saw the students holding up the banner and the media coming down the street filming the torch. Morse then ran across the street and asked them to take down the banner. Twelve of the students ran off, but Joseph Frederick stood his ground. Morse then proceeded to confiscate the banner and suspend Frederick.

It is important to understand some of the First Amendment precedents up to this point regarding student speech. Prior to 2002, there were two conflicting Supreme Court cases that had established precedent regarding the regulation of student speech: *Tinker v. Des Moines* (1969) and *Bethel School District v. Fraser* (1986). In *Tinker v. Des Moines* the Supreme Court had ruled in favor of students, arguing that if student protests were not disruptive, school officials could not censor student speech. In *Bethel School District v. Fraser*, the Supreme Court ruled in favor of the school.

Fig. 1. Joseph Frederick (courtesy of Associated Press).

Fig. 2. Students holding up the "Bong HiTS 4 Jesus" banner January 4th, 2002 (courtesy of Associated Press).

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

These two cases are important to consider because by the time Frederick had hoisted his banner it had been almost 20 years since the last Supreme Court case on the free speech rights for students, and there was conflicting legal precedent as well. It is also important to note that by 2002 the makeup of the court had changed.

After Joseph Frederick was suspended, the school then added a charge of criminal trespass, essentially banning Frederick from the school grounds. In the late 1990s and early 2000s, the city of Juneau was in the middle of a serious drug addiction and overdose problem. While Juneau is the capital of Alaska, it is also a small and isolated city. There are no roads to Juneau, and the city is only accessible by sea and air. Juneau's population is 32,000 people. While it is a city, it also has a feel of a small town, and the community is very close. Deborah Morse and the school board had claimed that the substance abuse crisis was on their mind when they made their decision to discipline Frederick and that they interpreted the banner as promoting drug speech. For much of the city's older generation, Morse was seen as doing the right thing. For much of the city's younger generation, Frederick was seen as a hero for standing up for First Amendment rights. Frederick had insisted the banner meant nothing and was simply a prank for television time.

Frederick first appealed his suspension to the school board claiming that the school violated his federal and state constitutional right to free speech. The school board sided with JDHS and upheld Frederick's suspension. Frederick then appealed his case to the U.S. District Court for the District of Alaska where the case was heard by Chief Justice John Sedwick. Justice Sedwick issued a summary judgment against Frederick, essentially making his ruling without holding a full trial. By this point the case was the main talk of Juneau and was dividing the town. Following Justice Sedwick's ruling, Frederick appealed the ruling to the 9th Circuit Court of Appeals where a three-judge panel, headed by Justice Andrew Kleinfeld, overturned the ruling of Justice Sedwick. This set the stage for an appeal to the U.S. Supreme Court, and on March 19th, 2007, the oral arguments were heard for *Morse v. Frederick*. Representing Joseph Frederick was the ACLU and Juneau Attorney Doug Mertz, and representing Deborah Morse was U.S. Solicitor General Ken Star.

The court ruled 5-4 against Frederick, stating that the First Amendment does not prevent school administrators from restricting student expression that is reasonably viewed as promoting the use of illegal drugs. In the end, Deborah Morse regretted ever getting involved. She became stigmatized and alienated and never understood why Frederick did not just let it go. Frederick saw himself as being on a moral crusade. The case of *Morse v. Frederick* later became very consequential for both free speech rights and future U.S. drug policy (Foster 2010).

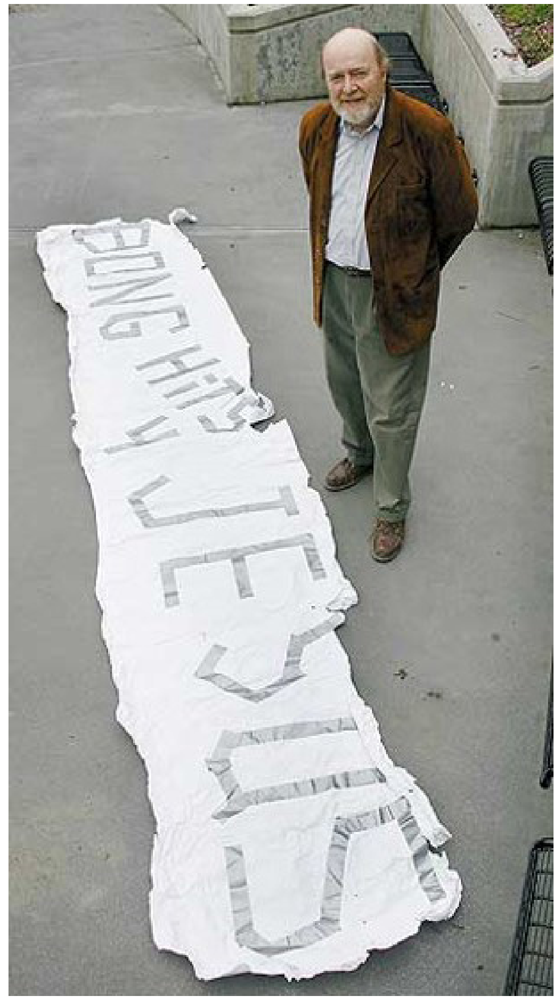

Fig. 3. The banner after being returned to Attorney Doug Mertz in 2002 from Morse's legal team (courtesy of Associated Press).

BONG HiTS 4 JESUS banner history

In 2002, at the height of the lawsuits, Attorney Doug Mertz was handed the banner by the Morse Legal Team. According to Doug Mertz, the banner was handed to him crumpled up in a bag (fig. 3), where it then resided on top of a cabinet in his office until 2007, when it was loaned to the Newseum in Washington, D.C. (Doug Mertz, pers. comm.). The banner then remained on display at the Newseum until 2019, when the Newseum galleries closed (fig. 4). The banner was then sent back to Alaska and returned to Doug Mertz. By this point, Frederick had moved to China with his family and was primarily interested in selling the banner. In the interest of keeping the banner in Juneau, Doug Mertz first approached the City Museum of Juneau, followed by the Alaska State Museum (ASM) (Doug Mertz, pers. comm.). Before the ASM would purchase the banner, a discussion was required to address its condition and potential display.

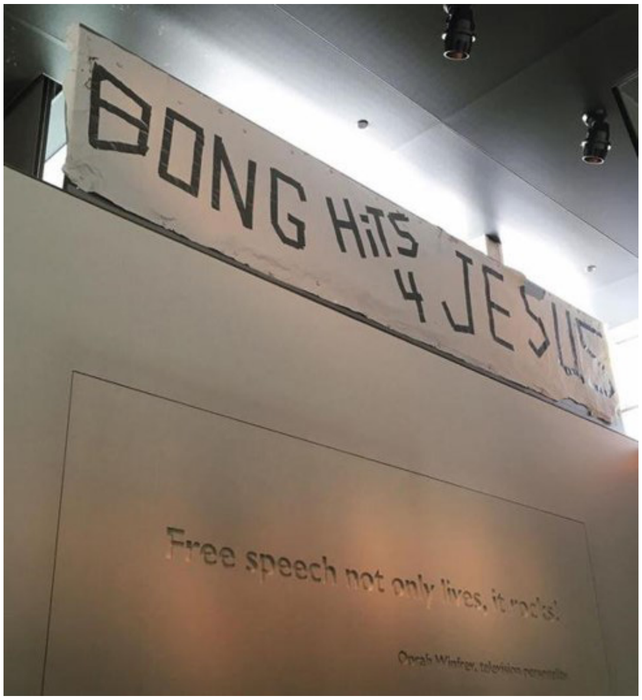

Fig. 4. The banner on display at Newseum (The Daily Nebraskan, Lani Hanson, Oct. 23, 2016).

ASM Conservator Ellen Carrlee initiated discussions with Paper Conservator Seth Irwin to discuss options. After the ASM decided not to acquire it, the banner was then purchased by the First Amendment Museum in Maine. The First Amendment Museum then decided to follow all the original conservation and display recommendations (Christian Cotz, pers. comm.).

MATERIALS, CONDITION, AND ETHICAL CONSIDERATIONS

The banner consists only of two materials: commercial butcher paper and silver duct tape. It was in poor condition, with damage consisting of heavy tearing and creasing (figs. 5 and 6). There was also crumpling across the whole sheet. The

Fig. 6. The banner unrolled in the studio.

entire sheet measured approximately 15 ft. There was approximately 47 ft. of cumulative duct tape across the length of the banner. Remarkably, none of the duct tape had either lifted or caused any noticeable deterioration after almost 20 years. In 2008, the Newseum had contracted out minor conservation work of the banner to Girod Holt Conservation LLC (Carrie Christofferson, pers. comm.; Jane Girot Holt, pers. comm.) (fig. 7).

From the beginning, it was clear that any action conducted with the banner would require serious ethical discussions. The damage to the banner was viewed as critical to its history. Everyone agreed it was important to keep the damage, but there was some discussion as to what damage was important to keep. The damage from 2002 was viewed as the most important, but it was agreed that all the damage that followed should be repaired. There were also very few photographs of what the banner looked like in 2002 after it was confiscated and held by the Morse legal team, and Doug Mertz claimed it was not well taken care of when it lived on top of his office cabinet for the five years following (Doug Mertz, pers. comm.). It also became clear that Joseph Frederick needed to be consulted. During the time it had been on display at the Newseum, magnets had been used to hang the banner

Fig. 5. Recto of the banner before treatment.

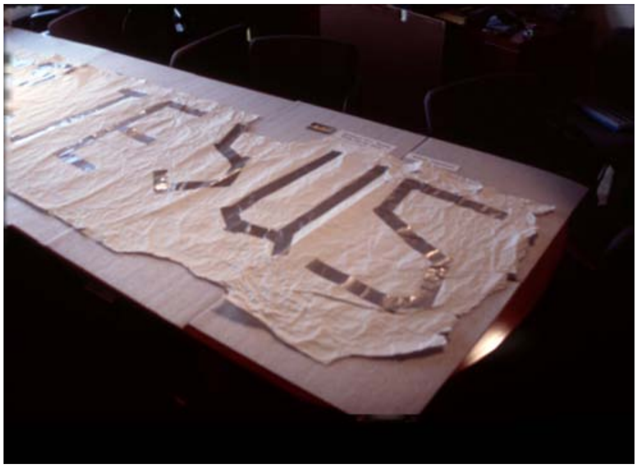

Fig. 7. The banner undergoing assessment and treatment by Girod Holt Conservation LLC (courtesy of Jane Girot Holt).

(Carrie Christofferson, pers. comm.). This method was seen as less than ideal for future exhibition goals.

Everyone agreed that there had to be a compromise on what damage should be repaired. Some damage needed to be repaired for the purpose of stabilization, even if it was original. For other areas of damage it was more important to maintain the aesthetic of the damage rather than preserve each crumple and crease. It was decided that no action would be taken on any of the 47 ft. of duct tape. None of the tape had lifted after 20 years, and no benefit was seen in attempting to intervene with any of it. All the tearing would be repaired, but all the tears still had to be visible. The crumpled look was important to keep, but it did not need to be the original crumpling. Most important was that the treatment needed to involve a new hanging system that would allow for the banner to be safely displayed and then rolled up when not on exhibit. A loop-based hanging system was devised that would come from lining the entire banner onto a single sheet of 100% unbleached cotton muslin, as opposed to a traditional Japanese paper. The idea was that this approach would be more durable on an object of this size, while also preserving much of the crumpling and creasing that might be removed with a traditional paper lining.

TREATMENT

The treatment for the banner called for a single lining onto a sheet of a high-thread-count, 100% unbleached cotton muslin. This lining approach was to be an open-air lining modeled after the relining of 19th century varnished wall maps. In this process, a single sheet of muslin would be wetted out on a piece of acrylic. The muslin would then be smoothed out. A dilute wheat starch paste would then be applied to the fabric. The object would be laid out on the fabric and smoothed out. The object would then be allowed to dry in open air. The process would be similar to the one used on maps but with several notable changes. The first would be the use of the excess fabric border on the top edge to create loops for a hanging system. The second would be the trimming of all remaining excess fabric to reproduce the original losses and damage to the banner.

Fig. 8. Acrylic sheets getting sanded down with 60 grit sandpaper to prepare for lining.

STEP 1: Several sheets of acrylic were sanded with 60 grit sandpaper to provide a surface with higher grip. The sheets were shimmed and taped from below to create a seam (figs. 8 and 9).

STEP 2: A single sheet of 100% unbleached cotton muslin was laid out across the acrylic sheets and wet out with water using a large wallpaper brush. The fabric was then stretched out using a Chinese palm brush (figs. 10 and 11).

STEP 3: Wheat starch paste was applied to the entire sheet using a large wallpaper brush (fig. 12).

STEP 4: The banner was slowly laid out on the fabric and smoothed out through Hollytex using a rubber printing

Fig. 9. Acrylic sheets getting shimmed and taped from below create a good seam.

brayer. The banner was then allowed to completely dry in open air.

STEP 5: Once dry, the banner was removed from the acrylic sheets and turned over. The top edge was trimmed to allow for an extra 2-in. border. Two-inch gaps were cut every 24 in. along the top border, and the remaining flaps were folded towards the verso and adhered with wheat starch paste to create loops. The fabric along the remaining sides and bottom were trimmed flush with the paper (figs. 13–15).

CONCLUSION

Objects of protest are not typically thought of as "artwork," and documentation of condition is often not considered when such pieces change hands. In the case of the banner, it

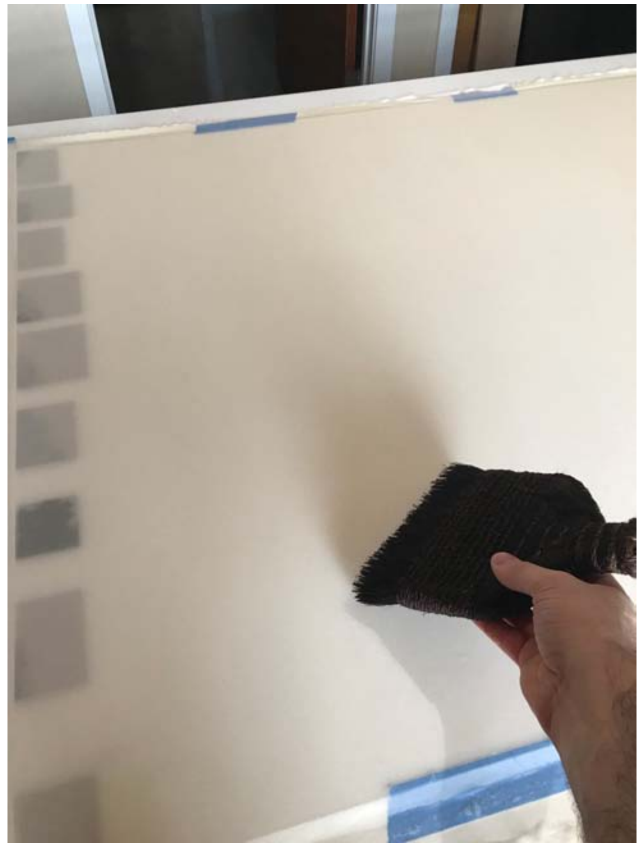

Fig. 11. Stretching and smoothing out the cotton muslin with a Chinese palm brush.

had changed hands so many times without documentation that there was no way to determine when all the damage had happened. When determining original damage is not possible, and when the object might require repair for stability, it might be necessary to "recreate" the prior damage—the look

Fig. 10. Wetting out the cotton muslin with water.

Fig. 12. Pasting out the cotton muslin with a paper hanger's brush.

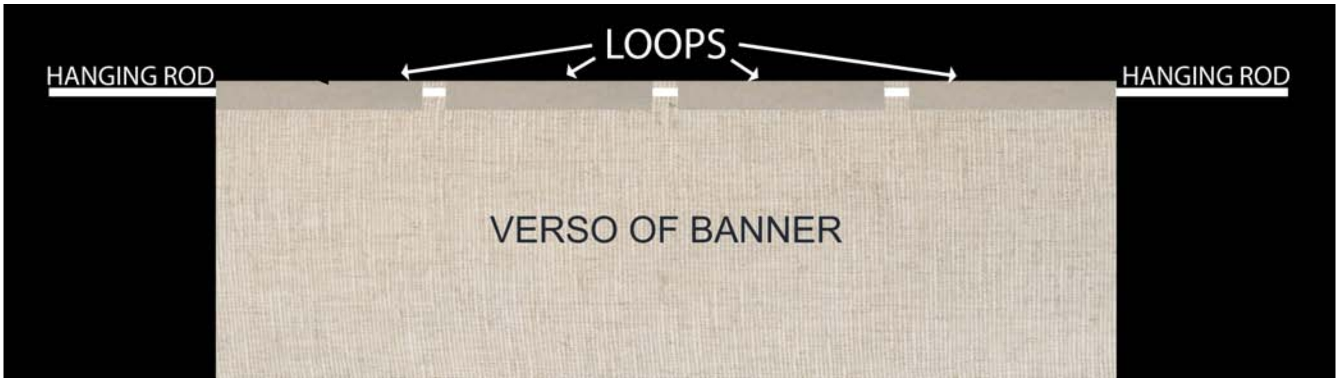

Fig. 13. Diagram of new loop hanging system.

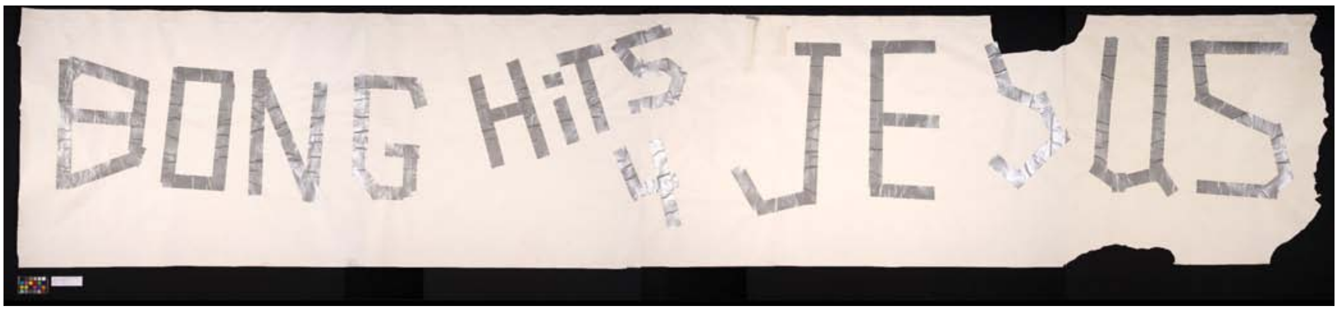

Fig. 14. Recto after treatment.

Fig. 15. Verso after treatment.

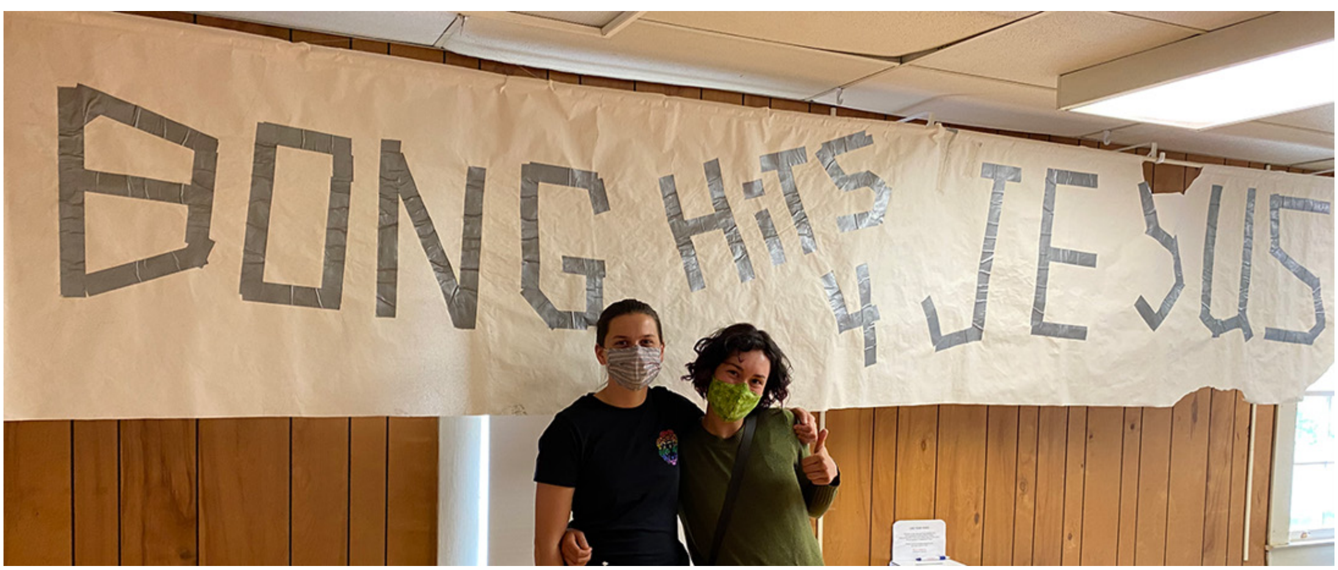

Fig. 16. The banner on exhibit at First Amendment Museum (courtesy of First Amendment Museum).

of the damage might be more important than its origins. As a final note and observation on this project: objects of historical protest and controversy may involve asking the original creators of the object to bring up a traumatic past that might cause discomfort. The banner is now on display at the First Amendment Museum in Augusta, Maine (fig. 16).

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Christian Cotz – CEO of First Amendment Museum
Jane Girot Holt – Girod Holt Conservation LLC
Joseph Frederick

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Chinoiserie/Chinese Export: A Comparison of Conditions and Treatments of Two Wallcoverings in Comparable Oceanside Environments

INTRODUCTION

The Jeremiah Lee Mansion is a wooden structure, constructed ca.1768 by a prosperous merchant in Marblehead, Massachusetts. It is best known for the hand-painted grisaille wall paintings produced in England and attributed to William Squire that were mounted at the time of construction in the prestigious public and private halls and rooms. It also had a variety of relief-printed English wallpapers, including one that survived from the date of construction, a considerably more modest Chinoiserie pattern in the third floor hallway covering 310 sq. ft. (fig. 1). Following Lee's death during the American revolution, the mansion served several residential and commercial purposes until the building was purchased for preservation in 1909 by what is now the Marblehead Historic Society.[1]

Rough Point is an 1891 masonry structure by Peabody & Stearns built for Frederick Vanderbilt on a promontory in Newport, Rhode Island. After its purchase in 1922 by James Duke, it was modified to include a two-story ballroom addition. Two different sets of ca.1780 Chinese export wall paintings that are sympathetic in design and scale were purchased at auction in 1958/1959 and mounted as framed sections around the room, covering 1000 sq. ft. (fig. 2). Rough Point became the summer home of the heiress Doris Duke, preservation philanthropist and founder in 1969 of the Newport Restoration Foundation.

In both cases, the building envelopes were well maintained, but the nature of their constructions, however different in primary materials and level of technology, did not include systems that could do more than mitigate the extremes of their interior environments. It was also clear that exposure to four seasons in their oceanside locations meant that they were particularly susceptible to the failure of building systems when they did occur. These include water penetration through the walls, rising damp, and compromises in the building envelope, especially during extreme weather conditions.

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COMPARISON OF SCOPE AND PARTICULARS OF TREATMENT

For the wallcoverings to be insulated from these conditions by remounting and for their supports and media to be stabilized, overall removal for studio treatment was the only viable strategy (fig. 3). However, because of their different paper supports, media application, mounting formats, degree of individually identified compromises in condition and appearance, and history of care, the overall treatment designs differed appreciably in their complexity and priority of treatment objectives. Therefore, the degree of intervention and the procedures and materials used were appreciably different. These differences can be highlighted by introducing the relatively more straightforward project first.

Marblehead English Chinoiserie wallpaper

However much the design of the Marblehead Chinoiserie wallpaper may have been a response to the taste for genuine Chinese decorative arts, it is a thoroughly 18th century example of a Western pattern wallpaper. The 21 1/4 in. wide rolls were assembled from overlapping sheets of heavyweight English laid paper, coated with an opaque aqueous medium ground layer on which the design with a 45 in. vertical repeat was block printed in a limited palette of lean aqueous media. The rolls were mounted with overlapping vertical seams directly to plaster without benefit of a lining of paper or fabric, for the most part on interior walls.

With the exception of several cracks, the plaster walls were sound with a granular final coat typical of the period. The paper exhibited planar distortions and widespread separation from the walls, marked fragility and numerous tears. There was overall discoloration from exposure, local areas of staining, tidemarks, and water damage. There were also localized areas of discoloration from the use of copper-based Blue Verditer pigment. The loss of media from cleavage and

Fig. 1. Ca. 1765 Jeremiah Lee Mansion, photo courtesy of the Marblehead Museum, and English Chinoiserie Wallpaper, photo Studio TKM.

Fig. 2. Ca. 1891/1922 Rough Point, photo courtesy of the Newport Restoration Foundation, and Ballroom with c. 1780 Chinese export wallpaintings, photo Studio TKM.

Fig. 3. Marblehead Chinoiserie and Newport Chinese export wallcoverings, photos Studio TKM.

abrasion was extreme, with the commonly seen phenomenon of media having survived better at overlapping seams where expansion and contraction are more constrained due to the additional thickness.

The wallpaper had been minimally cared for over its history, primarily through mending by readhesion directly to the plaster or by patching areas of loss with pieces cannibalized from locations where large sections of the wallpaper were removed. This includes the entire area below the current chair rail where the pentimenti of the original seams are visible. The wallpaper now survives in only one stretch of hallway, with furniture and framed portraits against the walls. Despite this catalog of damages, the wallpaper retains great integrity as it is mounted to the original plaster, complete areas of design can be located despite widespread loss, and the character of the materials and technology used for its production remain apparent. Finally, it has been spared from the application of overpaint.

Newport Chinese export wall paintings

In contrast, the lengths of Chinese export wall painting are laminates made up of three layers of bast fiber papers up to 44 in. wide, joined with narrow overlapping seams. The designs were informed by preliminary outlines on the reverse and painted with aqueous media in varying degrees of opacity over a uniform background of malachite. While these wall paintings are typical of Chinese works in their material execution and sense of design, as export works they were destined for Western interiors and the mounting format was a decidedly Western effort.

Unlike examples in other European and American venues, the wall paintings were not mounted using the well worked out systems of overall adhesion to fabric stretched over battens or adhered against plaster walls. Instead, up to three rolls measuring 135 in. in height and up to 126 in. wide were assembled as coherent compositions onto Masonite panels for display as sections surrounded by moldings, almost all of them against exterior walls. Records of their condition at the date of purchase are incomplete. Available sets of historic Chinese export wall paintings in the mid-20th century generally came from other locations, and the nature and extent of damage reflect this removal and relocation (this set was removed from ca.1791 Clyne Castle in Swansea Wales). Unfortunately, there was a long history of poor decision making associated with this mounting format and later campaigns of repair. Photos that survive reveal damage along the seams as far back as 1960 and color photos from 1983 clearly show the damage that necessitated the treatment described in this article.

The Masonite panels were joined with an awkward system of chamfered overlaps secured with adhesive, rivets, and reinforcing tape on the back. These were hung from screws set into the plaster and captured at the edges by moldings. The Masonite panels were prepared with a poor quality Western paper to which the painting sections were mounted overall using shellac and protein adhesives. The separation of the Masonite at overlaps and the failure of the adhesives generated large jagged tears in the wall paintings, as well as widespread areas of local separation from the panels. Interlayer separation of the original laminate structure and associated losses in the top layer of paper were also widespread. There was overall discoloration from exposure, contact with the poor quality Western lining paper and adhesives, and repair materials. The background malachite exhibited widespread loss. Earlier repairs were especially intrusive, including extensive poor quality overpainting as well as a thin application of a resin coating that was presumed to function as a consolidant or to uniformly saturate the design. To date, this project has been executed in two phases to address the three largest and most compromised assemblies, with the completion of the second phase awaiting repair of the building envelope.

TREATMENTS

Returning to the Marblehead Chinoiserie wallpaper, its treatment largely focused on consolidation of the surviving media, reinforcement by lining with handmade Japanese papers, and overall remounting using a traditional Western wall preparation of multiple layers of fabric with heavier machine-made Japanese paper to insulate the wallpapers and facilitate removal.

In comparison, the wall paintings in Newport are more of a distinguishing feature in the decorative scheme of a much larger and more formal public room. The authenticity of appearance was markedly compromised; therefore, the project objectives were more expansive, with a more complex treatment design. These included removal of the original support from the Masonite panels and linings, readhesion of the separated laminations of paper, and a new panel system for remounting. The most to-be-determined challenge was how and to what extent the design could be reintegrated in light of the background loss and overpaint.

In summary, the treatment of the Chinoiserie wallpaper and Chinese export wall paintings represent two extremes of overall conservation treatment. The different original supports and application of design media, mounting surfaces and formats, and degree of compromise necessitated different treatment objectives, using different technical procedures and materials, directed at what should always be individually tailored treatment designs. These differences become clear with a side by side comparison at similar stages of treatment.

Structural treatment comparisons

Since it was so poorly adhered already, the Marblehead paper was straightforward to separate at the seams and remove as rolls using steam, and laid out to dry before transport to the studio in cardboard folders with newsprint interleaves (fig. 4). In comparison, the overlapping Masonite panels from Newport were separated by reaching behind the large tears in the wall paintings caused by the separated overlaps and prying away or cutting the rivets and screws. The individual panels could then be lifted from the walls.

Unlike the Marblehead wallpapers, the Newport wall paintings needed considerable attention prior to their removal from the panels. After surface cleaning with fire recovery sponges, consolidation of some media with multiple applications of gelatin depending on their sensitivity, local separations were readhered using starch paste. To take advantage of the surface resistance afforded by the still rigid assembly, the overall resinous glaze was reduced as possible, primarily with acetone, and overpaint was reduced or removed as possible with solvents and moisture.

To protect and support the Newport wall painting sections during removal from the panels, 8 × 10 in. pieces of overlapping thin rayon paper were brushed on with water without adhesive. This first facing of small sheets of thin rayon paper conformed to and protected the fragile surface while also saturating the original support and linings. Steam introduced both through the facings, and from underneath once separation began, assisted as necessary (fig. 5). Following separation from the panel and additional reinforcement of the surface with a single large sheet each of heavier weight rayon and Mylar, the large sections were safely turned over for removal of the heavyweight western lining paper. The three layers of bast fiber paper were distinguished from each other by their relative quality, color, and weight. It was removal of the thicker, more coarse third layer of bast fiber lining paper that would make possible the readhesion and reinforcement of the original support by lining. In addition to reinforcing and protecting the surface during the backing removal and linings, the facing functions as an important element of the cleaning process by wicking away the solubilized discoloration.

Fig. 4. Removal of Marblehead Chinoiserie and Newport Chinese export wallcoverings, photos Studio TKM.

Washing of relief printed wallpapers is often possible using a system wherein the wallpaper rolls rest for a limited time on a slanted bed of blotters saturated with water from underneath. However, tests on the Marblehead wallpaper indicated that this degree of saturation would result in some blanching of the media. It was speculated by Susan Buck, who did the pigment analysis, that this could have arisen from solubilizing calcium carbonate that migrated from the plaster walls over two centuries of exposure. Instead, the Marblehead wallpapers were washed on a suction table using a water and alcohol mixture that was sufficient to allow consolidation with gelatin and subsequent lining.

Paper conservators understand well that exposure to moisture, however brief or extensive, contributes to the improvement in condition of the paper in addition to the

Fig. 5. Newport facing, removal from Masonite, removal of mounting remnants, photos Studio TKM.

Fig. 6. Stretch flattening Marblehead and Newport wallcoverings, photos Studio TKM.

reduction of general discoloration and tidemarks. Important additional benefits for the Marblehead paper were facilitating consolidation of the media and mitigating the potential for generating tidemarks that can occur during lining with an aqueous adhesive which can function as a surfactant. The critical benefit for the Newport wall paintings was reintegration of the original laminate structure using dilute wheat starch paste in combination with the stiff brushwork associated with lining. The Marblehead papers were left for the gelatin consolidant to dry before local mending and lining with two layers of handmade *kozo* paper (Paper Nao K36) using wheat starch paste, which served to fill the background losses. The Newport papers had losses reinforced from the back first with the lining, then with shaped patches followed by a third lining of heavier weight machine made *kozo* paper (Paper Nao RK9).

Both wallpapers and wall paintings were similarly flattened by humidification and stretch drying on sheets of 0.5 in. thick honeycomb board (fig. 6). These are a good alternative to the traditional *karibari*[2] when it is preferable to have the board bend somewhat to avoid over tensioning the object while drying and for projects where many panels are necessary. A large, even, unobstructed, and clean floor can also be used for lining and flattening oversize works.

Design compensation and remounting comparisons

The particulars of the Marblehead and Newport projects diverged again due to the individual strategies for design compensation and the remounting formats. It was agreed with the client that the Marblehead paper would remain archeological in appearance and therefore retouching was only carried out at a few tear edges and on the lining where visible under losses. The walls were prepared months beforehand with layers of pre-washed and shrunk cotton and heavyweight machine made Japanese paper (Paper Nao RK29), followed by sizing with wheat starch paste. During the actual remounting, it is critical to first hang the rolls dry to identify where edges should fall and, especially with pattern papers, to identify where each numbered roll should be located. It's also essential to apply enough adhesive (starch paste/cellulose ether combination) with the right viscosity both to prevent oversaturation and to lubricate adjustments in position—the surface sizing mentioned above contributes to this lubrication by preventing premature absorption of the adhesive (fig. 7). Rubbing the surface through newsprint protects the surface while promoting overall contact with the wall and absorbs excess moisture or adhesive that finds its way onto the surface.

For a wallpaper with the extent of design loss found on the Marblehead Chinoiserie wallpaper the modest aims were to improve the immediate condition and long-term stability and to have the historic surfaces appear as well cared for as the surviving condition allowed.

For the Marblehead wallpaper, constraining expansion and contraction to mitigate further cleavage of the media was the rationale for mounting overall to a rigid surface. On the other hand, for many Asian paintings that are thinner assemblies, it is preferable to accommodate seasonal expansion and contraction while providing overall support. The use of aluminum honeycomb panels covered on one side

Fig.7. Marblehead remounting, photos Studio TKM.

with matboard and the system of paper layers found on the Japanese screen surface[3] *(shitabari)* was identified early in the process as the preferred mounting format for the Newport wall paintings. The surface of the Japanese panel structure performs that function exceptionally well, in addition to providing ease of future removal of the paintings due to the *ukekake* release layer. A critical feature of the aluminum panels vs. the traditional lattice structure was their impermeability and isolation of the paintings from the exterior walls. The client also wanted a system that was easily removed in the event of an emergency. However, single honeycomb panels for sections three rolls wide (135 × 126 in.) would not fit through the doors to the ballroom so it was necessary to join separate panels that mirror in width the original seam locations of the wall paintings. Two procedures are particularly useful in mounting works this large. First, instead of marking where the corners of the panel would fall on the back of the painting sections, registration marks are made at the center of each side of both the panel and the painting. In this way, expansion of the object during mounting will not affect alignment. Second is to place two or more slightly overlapping sheets of Mylar on the reverse of the object after pasting to facilitate positioning of such large works—after the object is precisely registered and weighted at one end, the first Mylar sheet is removed to establish contact, after which the remaining sheets of Mylar are removed and full surface contact is made using the newsprint as explained above (fig. 8). With exposure to moisture concluded, a final round of local readhesion was undertaken prior to final inpainting.

In addition to their original material fabrication, scale, history of relocation, and subsequent damage, the Newport Chinese export wall paintings were distinguished from the Marblehead wallpaper by the irreversible remnants of overpainting. Some of this consisted of aqueous media but most was an insoluble opaque media thought to be acrylics. It was concentrated at tears, roll edges, and panel seams, and in the background of one of the two sets more than the other. The panels were reviewed by the client at this stage to have a full understanding of the technical, esthetic, and ethical options to address these conditions, as well as the extent of resources needed. Their involvement was essential for the credibility of the decision-making process. After reducing the overpaint as much as possible with solvents and moisture locally and repeatedly, areas of the most resilient acrylic overpaint were further reduced by abrasion to provide a suitable base for design compensation. In summary, in addition to the more routine inpainting at the many tears and losses, the overpaint remnants were overpainted themselves and the most disturbing areas of background loss were glazed using transparent and opaque watercolors, dry pigments, and pastels (fig. 9).

With the assistance of the Newport Restoration Foundation staff, reinstallation was straightforward when preceded by understanding what the choreography would be of lifting and joining the panels. The lower edge of the panel and the bottom molding on which they rested were both waxed. After

Fig. 8. Newport mounting section on panel, photos Studio TKM.

placement of the first, the neighboring panels were slid in place, aligned at the seams using horizontal dowels, secured to each other with small latches at the top and bottom edge of each panel, and then finally secured by the reinstallation of the moldings (fig. 10).

Clearly, the extent of overpaint removal and design compensation undertaken on the Newport wall paintings could be characterized as restoration in comparison to the conservation of the Marblehead wallpaper. That said, it is presented as a legitimate treatment design for an exceptionally damaged work. A variety of technical and esthetic options were proposed, a well-informed curatorial staff identified their preferences, the processes are largely reversible, and they were executed by experienced conservators familiar with the esthetics of Chinese export wall paintings. Design compensation made up 35% of the overall treatment time of 1700 hrs., for a project with a surface area of 270 sq. ft. (Phase 1). This amounted to 2.25 hrs. per sq. ft.—not extraordinary in comparison to projects for other works in comparable condition but, of course, still considerable because of the large surface area.

SUMMARY

In summary, what merits a presentation comparing these two projects? A priori, an in situ project using predominantly local treatment procedures should be the first option evaluated. However, it should also be understood that local treatment can be inadequate or a poor use of resources to address major compromises in comparison to overall removal, studio treatment, and remounting—especially when a previous treatment is outside the norms of practice as seen on the Newport wall paintings. Could these treatment designs have been flipped, with the Marblehead Chinoiserie wallpaper similarly reinforced by lining in the Asian fashion, mounted on panels in the Japanese style, and inpainted to complete the extensive loss of design? Could exposure to moisture of

Fig. 9. Newport design loss compensation with before and after details, photos Studio TKM.

Fig. 10. Newport panels secured within moldings with detail of panel alignment hardware, photo Studio TKM.

the Newport Chinese export wall paintings have been minimized, with the wall painting adhered directly against the plaster walls and minimal appreciable attention given to the overpainting? Both alternative scenarios seem inopportune as best practices or use of resources, even though in other circumstances Western wallpapers have been mounted on Japanese style panels and Chinese export wall paintings have been adhered overall to plaster walls. It's worth emphasizing that both mounting systems are reversible, by the use of a fabric layer at Marblehead and the *ukekake* layer at Newport.

In conclusion, different methodologies for overall treatment have particular materials, procedures, and assemblies associated with them that have merit based on their historic evolution. This comparison of projects illustrates that individual elements of these traditions can be imaginatively recombined to address the specifics and objectives of a project.

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NOTES

1. For discussion of the William Squire hand-painted grisaille landscape paper and contemporary pattern wallpapers in the Lee Mansion, see Catherine Lynn, *Wallpaper in America from the Seventeenth Century to World War I*, (New York: Norton, 1980), pp. 54–56, 75–79, and 99–106 and Judy Anderson, *Glorious Splendor: The 18th-Century Wallpapers in the Jeremiah Lee Mansion in Marblehead, Massachusetts* (Virginia Beach: Donning Co. 2011).
2. For discussions of the *karibari* structure, see Koyano, M., *Japanese Scroll Paintings: A Handbook of Mounting Techniques* (Washington, D.C.: Foundation of the American Institute for Conservation, 1979); Webber, P. and M. Huxtable, "Karibari—the Japanese drying board," *The Paper Conservator 9* (1985): 54–60. The Institute of Paper Conservation, London 1985.
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SOURCE OF MATERIALS

Photographic grade gelatin, water soluble cellulose ethers, Zin Shofu wheat starch paste TALAS, 330 Morgan Ave., Brooklyn, New York 11211 USA
https://www.talasonline.com

Japanese paper
Paper Nao
4-37-28 Hakusan Bunkyo-ku, Tokyo, 112–0001 Japan.
https://www.papernao.com/

Rayon paper
Hiromi Paper Inc
9469 Jefferson Blvd., Suite 117, Culver City, CA 90232
https://hiromipaper.com

Japanese mounting brushes (hake)
Kobayashi Hake Co.
5-7-5 Fujisaki, Narashino-shi, Chiba, 275-0017 Japan

Aluminum honeycomb panels
Small Corp.
19 Butternut St, Greenfield, MA 01301
https://www.smallcorp.com

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RACHEL MOCHON

Nanocellulose in Practice: Properties of Microfibrillated Cellulose and Cellulose Nanocrystals

INTRODUCTION

Nanocellulose is a term encompassing several highly refined cellulosic materials prepared by mechanical and/or chemical processes to isolate the smallest part of the cellulose fiber. Within the past decade, paper conservators have begun to study this material for its sustainability, strength, transparency, and chemical stability. It has also been tested and incorporated into many industries, including medical, food, cosmetics, and electronics. More familiar applications of nanocellulose outside of the conservation field include dermal poultices, the SCOBY or mother used in fermentation of kombucha, and Nata-de-coco, an authentic dish from the Philippines consisting of bacterial cellulose from the fermentation of coconut water.

There are three main types of nanocellulose: microfibrillated cellulose (MFC), cellulose nanocrystals (CNC), and bacterial cellulose (BC). Cellulose can be prepared from multiple sources, including wood, cotton, tunicate, algae, and bacteria (Dufresne 2012, 3). Both MFC and CNC, however, are primarily prepared from plant matter. The terminology is highly inconsistent for these three kinds of nanocellulose. The following terms listed in Table 1 are used to describe the same product by various sources. Distinguishing between the three types is essential, as they have very different chemical and physical characteristics.

Microfibrillated cellulose (MFC) is likely the most common nanocellulose currently being tested within the field of conservation. The diameter of the fibers can range from 5–100 nm (Völkel et al. 2017, 2), and lengths range from 1–10 µm (Dreyfuss-Deseigne, 2017a, 22). As such this form of nanocellulose is known as both "microfibrillated cellulose," referring to the length of the fibrils on the micrometer scale, or synonymously "nanofibrillated cellulose," referring to its width on the nanometer scale. To produce MFC, a wood or plant-based pulp may first undergo chemical, enzymatic, or mechanical treatments to purify the cellulose and remove impurities, such as hemicellulose and lignin (Dreyfuss-Deseigne 2017a, 21). Next, a heavy mechanical shearing process fibrillates the fibers, and the microfibrils are isolated (Dreyfuss-Deseigne 2017c, 110). The resulting gel or slurry contains both crystalline and amorphous cellulose.

The second type, cellulose nanocrystals (CNC), differs from the first type primarily in that it does not have the amorphous region of the cellulose, but only the crystalline portion. It is prepared by acid hydrolysis, using primarily solutions of hydrochloric or sulfuric acid, which break down the amorphous regions and leave behind the rod-like crystalline structure (Habibi, Lucia & Rojas 2010, 3483–4). The fiber width ranges from 3–25 nm, while the length is smaller than MFC, ranging from 0.1–2 µm (George 2015, 49).

Bacterial cellulose (BC) can be grown from many types of bacteria, but the *acetobacter* species is the only type to produce enough cellulose for commercial purposes (Dufresne 2012, 125). The bacteria is cultured in a medium, including sucrose and yeast-extract, in a lab over time. A pellicle forms on the surface of the medium and thickens, as the cellulose grows. The cellulose can then be rinsed and purified, removing the bacteria (Iguchi, Yamanaka, and Budhiono 2000, 263). The resulting fiber width ranges from 70–130 nm, and the length ranges from 1–20 µm (Dufresne 2012, 127). Of the three types of nanocellulose, BC has the highest degree of purity because there are no plant-based impurities (Dufresne 2012, 125).

CURRENT RESEARCH

In 2017, Rémy Dreyfuss-Deseigne published several articles presenting methods for casting MFC films, results of accelerated aging, strength testing, and color measurements, as well as applications of the films as a mending material for transparent papers (Dreyfuss-Deseigne 2017a, 2017b, 2017c). Several researchers have further explored the use of MFC as a mending and fill material for transparent papers (Knauf and Utter

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

Microfibrillated Cellulose	Cellulose Nanocrystals	Bacterial Cellulose
Fiber width: 5–100 nm	Fiber width: 3–25 nm	Fiber width: 70–130 nm
Fiber length: 1–10 μm • Microfibrillated cellulose (MFC) • Nanofibrillated cellulose (NFC) • Cellulose microfibrils • Cellulose nanofibrils • Cellulose nanofibers • Nanocellulose (generally)	Fiber length: 100–2000 nm • Cellulose nanocrystals (CNC) • Nanocrystalline cellulose (NCC) • Whiskers • Microcrystallites • Cellulose nanowhiskers	Fiber length: 1–20 μm • Bacterial cellulose (BC)

Table 1. Terms for Three Kinds of Nanocellulose

2020; Canham 2022; Henniges et al. 2022), and recently Liquitex® Professional acrylic inks were introduced as a compatible colorant for toning MFC (Henniges et al. 2022). To date, various suspensions of BC, MFC, and CNC have been explored and tested to reinforce or consolidate deteriorated paper, in applications by brush or film applicator on a vacuum suction platen or table, by lining, and by spray (Santos et al. 2016a & 2016b; Gómez et al. 2017; Völkel et al. 2017; Völkel et al. 2020; Ma et al. 2021; Opermolla et al. 2021).

The aim of this paper is to assess the differences between the three types of nanocellulose, their various physical forms, and compatibility with additives and colorants. The use of toned MFC in the consolidation of Letraset dry transfer lettering on three works on paper by Mira Schendel will also be discussed.

POLARIZED LIGHT MICROSCOPY

The preparation of nanocellulose fibers requires highly specialized technologies, so three kinds of nanocellulose were purchased from different companies (fig. 1). Celova, a ~3% suspension of MFC in water, is sold from Weidmann Fiber Technology, and CNC from Celluforce was available in two forms, as a dry powder and as a 6.3% suspension. Lastly, Hydronan BC at a concentration of 0.3–0.5% was purchased from JeNaCell.[1]

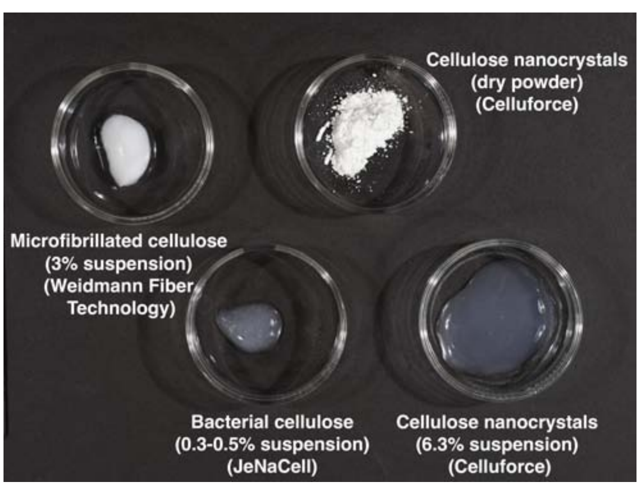

Fig. 1. Four different nanocellulose products as they arrived from three different manufacturers.

While transmission electron microscopy and atomic force microscopy are preferable for isolating nanocellulose fibers on such a small scale, polarized light microscopy provided information on the fibers' morphology and their scale.

Figure 2 compares five micrographs at 100x of the four forms of nanocellulose and typical unbleached softwood kraft fibers. Compared to the softwood kraft fibers (fig. 2a), the MFC sample (fig. 2b) is extremely fibrillated on a much smaller scale, and there are no intact fibers present. While the manufacturer identified the raw material as "softwood cellulose pulp," characteristic features of softwood, such as pitting, were not visible in the processed MFC pulp.

A C-stain was applied to the samples to further investigate the raw material sources. A C-stain is a solution that causes a color change in the fibers that can be indicative of the raw material source or specific pulping processes. The color change seen in the MFC sample was compared to known stain references in the literature (Graff 1940) and most closely matched softwood bleached kraft paper fibers or high alpha cellulose fibers.

Comparing the four forms of nanocellulose (fig. 2b–e), it becomes evident just how different these materials are, both in fiber size and morphology. Even the samples of CNC prepared at the same concentration from the slurry form (fig. 2c) and powdered form (fig. 2d) exhibit extremely different morphologies. Cellulose nanocrystals also have unusual rheological properties, as they exhibit liquid crystalline behavior (George 2015, 49). Both samples C-stained a violet-blue color with the naked eye. The C-stain did not narrow down the raw material beyond "wood pulp," as several known fiber species also C-stained to a similar color. While the source of the bacterial cellulose was known to be bacteria, the sample (fig. 2e) C-stained a bright orange, a similar color to jute or groundwood, but still much darker. While microscopy revealed information of scale and morphology, how the structures of these materials relates to their function remained an open question.

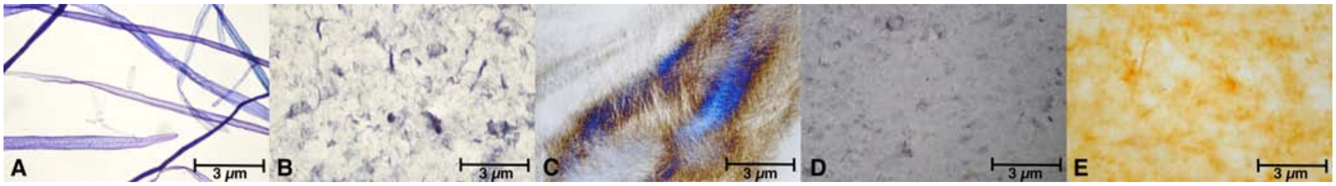

Fig. 2. Five micrographs at 100x magnification (left to right): (A) unbleached softwood kraft fibers, (B) 3% MFC from Weidmann Fiber Technology, (C) 3% CNC prepared from Celluforce pre-made suspension, (D) 3% CNC prepared from Celluforce dry powder, (E) 0.3–0.5% Hydronan BC from JeNaCell.

COMPARING CAST MFC AND CNC

MFC and CNC films were prepared with various additives and colorants to assess their effects on the working properties of the sheets. Dry sheets of MFC and CNC were both prepared using a cast-evaporation method, by which a suspension was prepared by mixing with a magnetic stir bar, poured into a petri dish, and allowed to air-dry (Dreyfuss-Deseigne 2017a, 22).

The MFC suspensions were prepared at 0.2–0.3% by weight, and 20 mL of the slurry was poured into a polystyrene dish. A square dish (9 × 9 cm) can be flexed to help release the film from the base after drying. Other conservators have used silicone petri dishes (Knauf and Utter 2020, 53; Knauf 2019) and Teflon trays (Robin Canham, e-mail to the author, November 2021). Casting a film at 0.1% by weight or lower can result in a film that is too thin and will stick to the bottom of the plastic petri dish, making it unusable. MFC at any concentration will stick to the bottom of a glass dish.

An internal sizing of methyl cellulose, added to the slurry prior to casting, improves the integrity and strength of the sheet, as well as its removal from the petri dish. Films prepared with MFC and methyl cellulose have an observed increase in transparency and mechanical strength compared to sheets without it (also observed by Henniges et al. 2022, 42). Nevertheless, both MFC prepared on its own or with methyl cellulose will wrinkle easily and exhibit strong electrical static charge (fig. 3). Because of their nanoscale, these fibers are extremely hygroscopic, making the dry films highly reactive to moisture and incompatible with many water-based conservation materials.

Additional additives, adhesives, and colorants were incorporated to assess how they would change the properties of the dry films. Several sheets were prepared with the addition of Ethulose, Klucel G, or Aquazol 500 to the slurries prior to casting. These adhesives contributed a subtle crisp quality to the films and made them more likely to tear along the edges. The sheets also responded well to toning with the addition of watercolor to the solution prior to casting.

Separate CNC slurries were prepared from the two manufacturer's forms, the dry powder and 6.3% pre-made suspension. The pre-made suspension was slightly yellow in

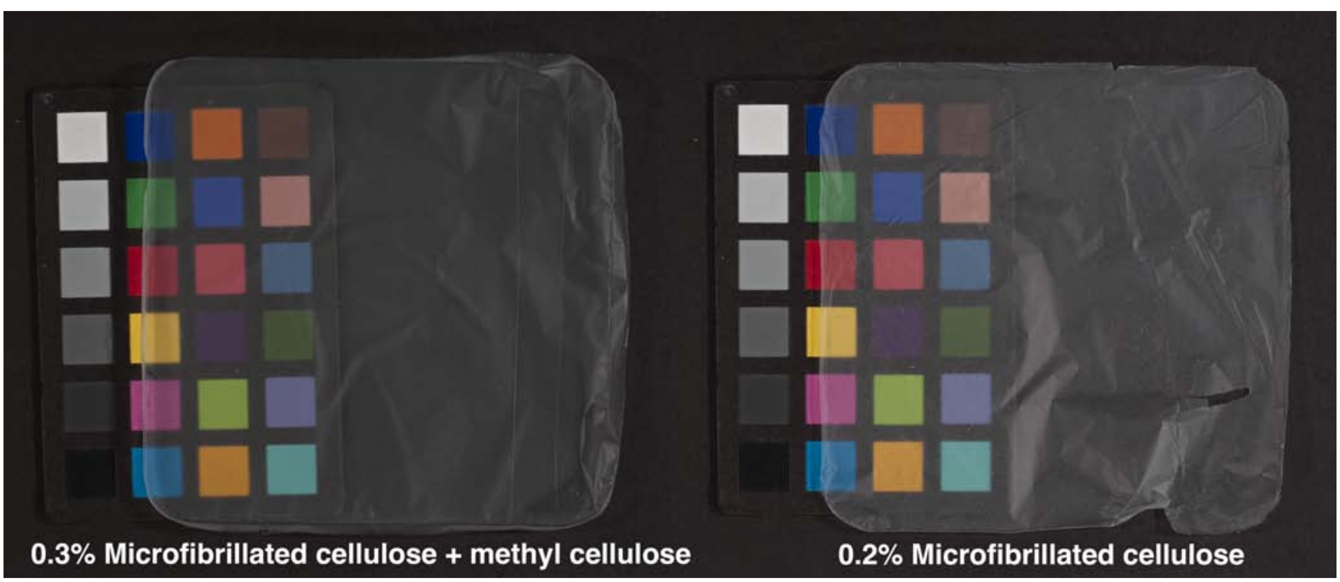

Fig. 3. A 0.3% MFC film prepared with methyl cellulose (left) exhibits slightly more transparency than a 0.2% MFC film (right).

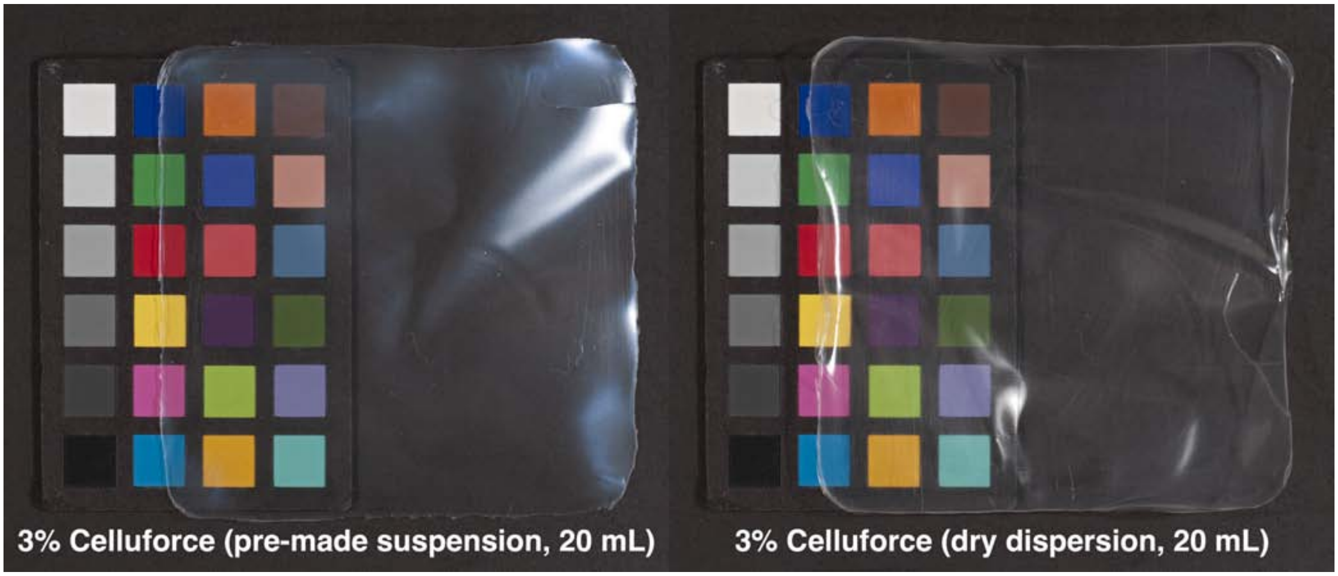

Fig. 4. While both 3% CNC films have about the same hardness, transparency, and flexibility, the sample prepared from the pre-made suspension (left) exhibits more iridescence than the sample prepared from the powder (right).

color and exhibited interference colors or iridescence. When the dry powder was dispersed in water, it formed a similar gel-like suspension but with less iridescence. Cellulose nanocrystals have different rheological properties than MFC, and the mixtures prepared are much more gel-like than MFC suspensions. CNC must be cast at a higher concentration, typically between 1.5 and 3%, compared to the MFC fibers cast at 0.3%.

Unlike the MFC, the cellulose nanocrystal films readily separated from the petri dishes without the addition of a sizing agent. In fact, the CNC films pull away from the petri dish during drying and do not lie flat. Adequate volume of the suspension must be added to the petri dishes to avoid the formation of large central holes and cracks in the film, which speak to the strong internal forces pulling the slurry to the edges of the dish. In figure 4, the CNC sample prepared from the powder exhibits less iridescence than the CNC film prepared from pre-made suspension. However, both samples had about the same hardness, transparency, and flexibility when prepared at the same concentration. For the purpose of comparison, a CNC sample was also prepared with methyl cellulose and took over four days to dry, speaking to its extreme hygroscopic nature. The sheet exhibits about the same transparency as other CNC films, but it is slightly less shiny and a little softer. Most significantly, the methyl cellulose improved the issue of distortion, and the sheet dried completely flat.

While MFC and CNC films behave nothing like paper, they may have applications in the treatment of synthetic papers or plastics as they share many of the same visual and physical properties. Their thinness and transparency are comparable to other translucent papers and films used in conservation (fig. 5). However, MFC often only *appears* more transparent than Japanese tissue because it does not exhibit long individual fibers. The extremely short fibers of the MFC and CNC make it impossible to create a feathered edge. Nanocellulose films must be cut with a hard edge, which in many instances may make a nanocellulose mend more visible than one of Japanese paper. The suitability and visibility of nanocellulose in treatment applications varies greatly depending on the substrate and materials, but it may be a highly compatible material with some of artists' less common and most unusual materials.

TREATMENT APPLICATION: TONED MFC AND LETRASET DRY TRANSFER LETTERING

As part of a campus-wide conservation initiative at the Harry Ransom Center, the treatment of several works by Mira Schendel featuring cracking and delaminating Letraset letters (fig. 6) prompted further testing of colorants in MFC and CNC samples. Letraset is a proprietary dry transfer lettering system composed of layers of ink printed on a clear film with a layer of pressure-sensitive adhesive (Vinelott 2021). MFC's smooth surface, thinness, and lack of visibly distinguishable fibers strongly resemble the surface of the transfer lettering. As such, MFC could serve as a possible fill material for the open cracks that no longer realign in Schendel's lettering (fig. 7).

Three methods of introducing color to MFC and CNC were tested: (1) adding colorant to the slurry prior to casting, (2) dyeing the films with Orasol dye dissolved in solvent, and (3) applying solvent-based Gamblin Conservation Colors to

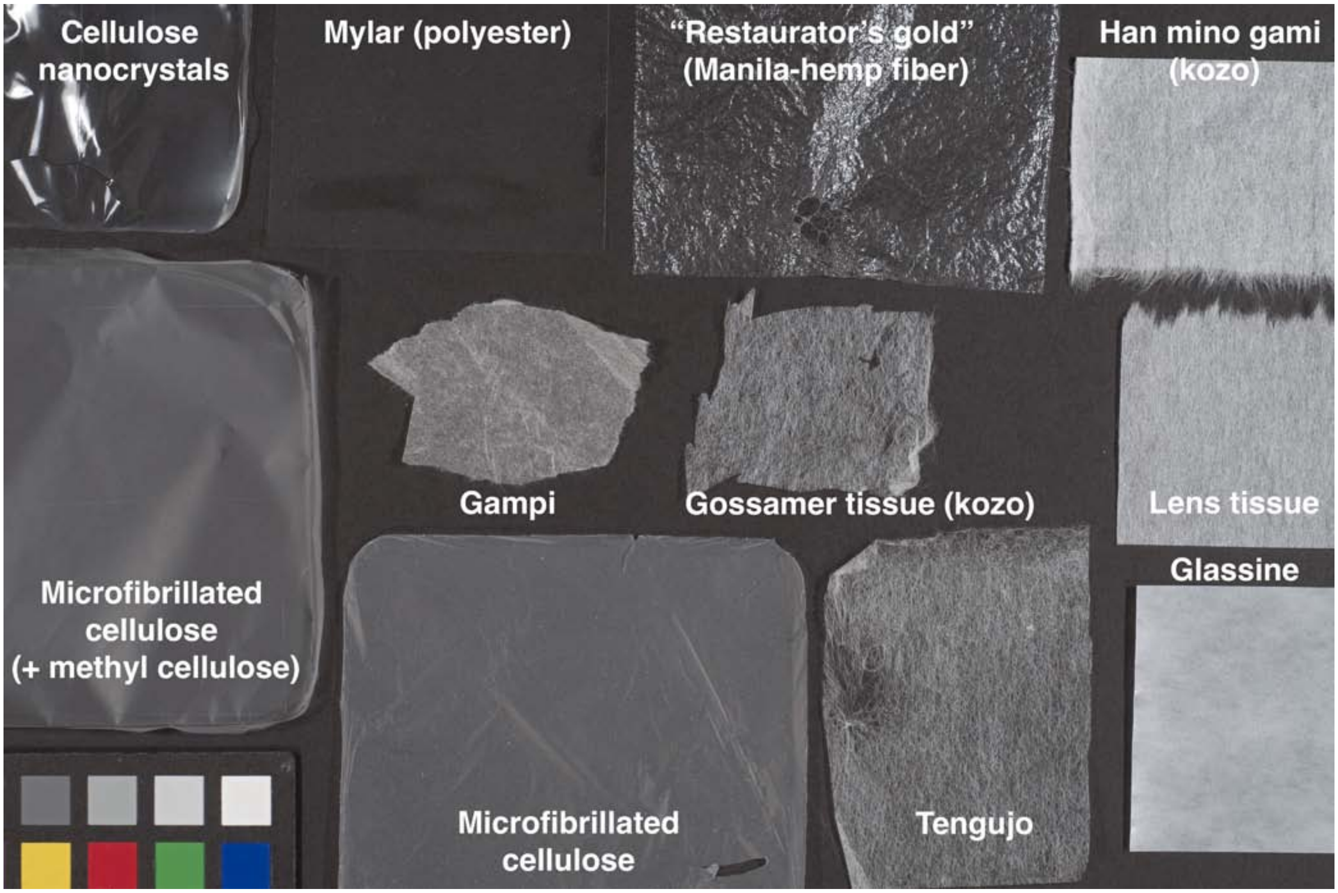

Fig. 5. MFC and CNC compared to a selection of thin, transparent papers and films used in conservation.

the dry films. These methods were selected due to the reactivity of nanocellulose to moisture when dry.

The various colorants added to the slurries included watercolors, gouache, dyes, and inks (fig. 8). While the unknown additives of proprietary formulations may raise questions of suitability for conservation, the interactions with MFC and CNC in terms of distribution, coloring power, and opacity were assessed. MFC films prepared with watercolor and gouache appeared to be the most successful in terms of distribution, opacity, and working properties, as most of the other films would not release easily from the petri dishes, possibly due to their additives.

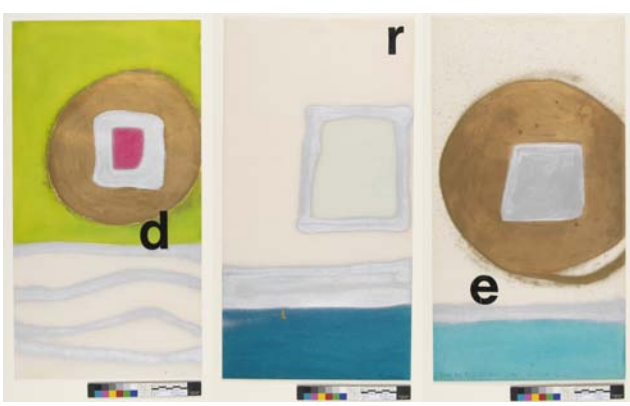

Fig. 6. Mira Schendel, Three *Untitled* works from the series *Spray*, 1970, Letraset transfer lettering, spray paint, and watercolor on paper, Blanton Museum of Art, The University of Texas at Austin, Archer M. Huntington Museum Fund, P1970.3.1, P1970.3.2, and P1970.3.5.

Fig. 7. Micrograph detail of the delamination and the open cracking in the Letraset "r" in one of Schendel's *Untitled* works (P1970.3.2).

Fig. 8. Dry samples of 0.3% microfibrillated cellulose prepared with the addition of colorants to the slurries prior to casting in a petri dish. Colorants included Winsor & Newton (W&N) watercolors and gouache, Golden Fluid Acrylics, various inks, and dye.

Next, MFC and CNC films were dip-dyed or brushed with black Orasol dye RLI, which is a 1:2 chrome metal complex prepared by dissolution in ethanol (Ciba Specialty Chemicals 2001, 3) (fig. 9). The use of 99.5% ethanol allowed for submersion of the hygroscopic films but still caused very minor distortions to the sheets. Uniform application also proved challenging, as tidelines formed in the sheets, even when held vertically with tweezers during drying. The CNC collapsed at the point held by the tweezers. Although the samples dip-dyed in 2.5% and 5% were relatively opaque, the 5% dye continues to transfer and offset after the films are dry. Application by brush on top of blotter was more controllable in terms of saturation but also led to tidelines. Furthermore, the way these films may be used has yet to be explored as the dye remains soluble in ethanol, complicating applications using solvent-based adhesives.

Finally, Gamblin Conservation Colors were applied to nanocellulose films as an inpainting material. Gamblin Artist's Colors are paints made from pigments, resins, and mineral spirits that are soluble in solvents such as ethanol. In several samples, the paint was brush-applied after the film had been adhered to the support paper using 5% Klucel G in ethanol or Lascaux 498 HV in acetone. This was a more successful approach than painting and then adhering the film, as the solvent-based adhesive could re-solubilize the paint and cause offsetting on the substrate. In these applications, the MFC and CNC films would serve as a barrier layer between the support and the Gamblin paint.

Development of the most appropriate technique in the treatment of the Mira Schendel works on paper is ongoing (fig. 10). Samples of MFC, untoned and toned with watercolor, are being tested alongside 1972 Letraset samples. Testing has indicated Letraset is sensitive to solvents, including ethanol and acetone, as well as heat, posing challenges for the attachment of the MFC below the open cracks. However, application techniques using MFC films as a remoistenable tissue have proved promising (Canham 2022).

CONCLUSION

Nanocellulose is a complex material. It does not behave like Japanese paper and other more traditional materials used in conservation. The properties of nanocellulose go far beyond its extreme transparency. While MFC films are thin and wrinkle easily, CNC films are hard and vary in flexibility

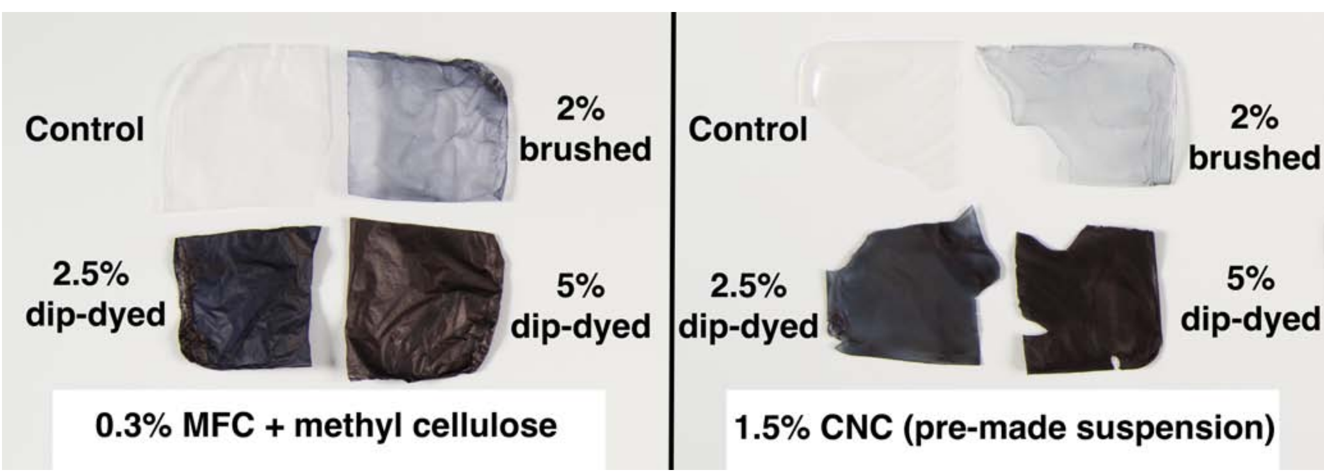

Fig. 9. Samples of 0.3% MFC prepared with methyl cellulose (left) and 1.5% CNC prepared from the pre-made suspension (right) were cut into quarters, and Orasol-dye was applied to three pieces of each sample. Samples in the upper right were toned by brush-applying 2% Orasol dye. Samples in the lower left and lower right were dip-dyed with Orasol dye at 2.5% and 5%, respectively.

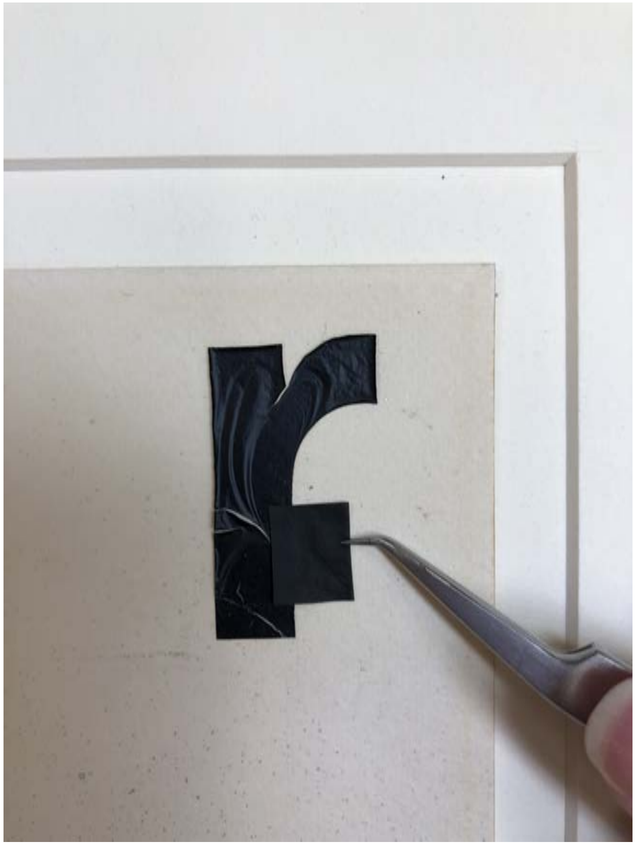

Fig. 10. Detail of Mira Schendel's Letraset alongside a sample of 0.3% MFC toned with watercolor.

and sheen depending on their preparation. The addition of methyl cellulose as a sizing agent may be used in both MFC and CNC films. When added to a MFC slurry prior to casting, methyl cellulose increases the transparency and strength of the film when dry, and in CNC, methyl cellulose appears to improve issues of distortion upon drying. Both MFC and CNC respond well to toning through the addition of watercolor to the suspensions before cast-evaporation. As such, nanocellulose films provide a range of surface textures, hardness, thicknesses, and opacities that may be compatible with translucent or synthetic papers, plastics, and some of artists' most unusual materials.

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NOTE

1. When purchasing any material for use in conservation, there are always questions of the safety of these materials for collection objects, and much more research is still needed. Preliminary results of analytical testing suggested that some of these materials from specific manufacturers may contain more than just cellulose, so the safety of some nanocellulose materials may vary depending on the proprietary preparations of different manufacturers.

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SOURCES OF MATERIALS

Cellulose Nanocrystals
CelluForce Inc.
2000 McGill College Avenue, 6th Floor
Montreal, Quebec, H3A 3H3
Canada

Celova for Art Conservation
Weidmann Fiber Technology
Neue Jonastrasse 60
8640 Rapperswil SG
Switzerland

Hydronan, Bacterial Cellulose
JeNaCell—An Evonik company
Göschwitzer Str. 22
07745 Jena
Germany

Gamblin Conservation Colors and Orasol Dye
Museum Services Corporation
385 Bridgepoint Way
South St. Paul, MN 55075
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Investigating the Effects of Rigid Polysaccharide Gels on Several Paper Sizings

INTRODUCTION

Since about 2003, rigid polysaccharide gels have been an area of interest and experimentation in the library and paper conservation specialties. Despite a growing body of studies and publications, this new material still requires research.

Based on the lead author's personal experience and an anecdote told by Michelle Sullivan at the 2017 *Gels in Conservation Conference* (2017, 19.1 min), concerns were raised about potential interactions between gellan gum and gelatin-sized papers. Contact with gellan gum seemed to be correlated with paper discoloration and darkening after artificial degradation despite the use of interleaving papers during treatment. Conversely, discoloration and darkening were not observed where agarose gel blocks were used for spot testing. These observations were made under conditions that did not allow for conclusions to be drawn.

Goal/Rationale

The initial goal of this research was to determine if contact with gellan gum negatively affects the long-term preservation and aging characteristics of gelatin-sized papers when compared to agarose treatment. However, during this experiment's development, it was discovered that the brand of gellan gum being sold was affected by supply chain issues that have not been communicated to the conservation field. In addition, the literature review revealed that gel-specific interactions with common paper sizings had not been previously researched. As a result, the project expanded from focusing on potential reactions between gellan gum and gelatin sizing to the potential effects of various rigid polysaccharide gels on several common paper sizings. Effects were evaluated with commonly used techniques and instruments to make the experiment easier to reproduce and compare with other experiments and similar data sets.

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

Literature Review

Book and paper conservators began experimenting with rigid gels because of their many preparation, modification, and application advantages. Rigid gels have been used successfully for local stain reduction, overall bathing, humidification, backing and attachment removal, aqueous and solvent-based adhesive reduction, and measuring surface pH and conductivity (Warda et al. 2007; Iannuccelli and Sotgiu 2010; Möller 2014; Sullivan, Brogdon-Grantham, and Taira 2014; Maheux 2015; Kwan 2016; Hughes 2017; Prestowitz 2017). Research has been conducted on their molecular structure, formulation, application, mechanism, cleaning efficacy, residues, compatibility with various additives and interleaving, and effects on certain physical and optical properties (Armisén and Galatas 2000; Sworn 2000; Tuvikene et al. 2008; Miyoshi 2009; Iannuccelli and Sotgiu 2010; Botti et al. 2011; Picone and Cunha 2011; Casoli et al. 2013; Isca 2014; Mazzuca et al. 2014a, 2014b, 2014c; Micheli et al. 2014; Cremonesi 2016; Hughes and Sullivan 2016; Kavda et al. 2016; Barbisan and Dupont 2017; Bertasa et al. 2017; Cremonesi and Casoli 2017; Sullivan et al. 2017). However, research focusing on the potential interactions between rigid gel and paper sizings is limited.

Related published research on paper sizing found gellan gum extracted significantly less gelatin sizing than immersion bathing when treating 16th-, 17th-, and 18th-century papers, which is potentially due to gel pore size and protein morphology (Isca 2014, 137–155). Other articles incidentally mention sizing: Hughes (2017, 62) states the type and amount of sizing disproportionately affects traditional surface pH readings. Iannuccelli and Sotgiu (2010, 34–35), Möller (2014, 44–45), and Micheli et al. (2014, 7) all note the amount of sizing has a crucial impact on the efficacy of rigid gel treatment and/or most effective gel concentration. Warda et al. reiterate advice shared by others that rigid gels should not be directly applied to unsized papers to prevent tide lines (2007, 274). Sullivan et al. observed that the hydrophobicity of sized papers reduces residue deposition, and the removal of gelatin sizing was observed as decreased autofluorescence in handmade rag paper that included samples with a barrier tissue (2017, 47–49). Möller et al. note that gelatin- and

Treatment Type			Paper Type				
Gel Type	Application	Artificially Degraded	Whatman	Antique Gelatin	Modern Gelatin	Alum Rosin	Starch-based AKD
Controls	No Gel	No	5	5	5	5	5
		Yes	5	5	5	5	5
	Water	No	N/A	N/A	N/A	N/A	N/A
		Yes	5	5	5	5	5
2% Ticagel Gellan Gum	Direct	No	5	5	5	5	5
		Yes	5	5	5	5	5
	Interleaved	No	5	5	5	5	5
		Yes	5	5	5	5	5
2% Kelcogel Gellan Gum	Direct	No	5	5	5	5	5
		Yes	5	5	5	5	5
	Interleaved	No	5	5	5	5	5
		Yes	5	5	5	5	5
5% Agarose	Direct	No	5	5	5	5	5
		Yes	5	5	5	5	5
	Interleaved	No	5	5	5	5	5
		Yes	5	5	5	5	5
Total Samples of Each Paper Type:			75	75	75	75	75

Table 1. Breakdown of experiment paper-treatment-application groups

synthetic-sized papers exhibited similarities in Delta E and morphological changes as opposed to unsized papers (2014, 44). Warda et al. found discoloration occurred after artificially degrading gelatin-sized watercolor papers treated with Carbopol and Laponite without interleaving but not in papers treated with agarose or methylcellulose (2007, 274).

Warda et al. also suggest reactions between poultice residues and paper components, such as sizing or fillers, could cause discoloration after artificial degradation (2007, 274). Sullivan extrapolates on this during her *Gels in Conservation Conference* presentation and postulates the discoloration seen in gelatin-sized papers treated with gellan gum may be caused by the two materials interacting with each other (Sullivan 2017, 19.4 min). This is plausible, since they are easily combined at 80°C–90°C (Shim 1985, 2; Kwang et al. 2003, 796; Yueyuan et al. 2018, 4767)—a common temperature range for artificial degradation of paper (Porck 2000, 16–18). Huber presents the Maillard reaction as another possible cause of browning in papers aged at 180°C–200°C and treated with gellan gum containing particular fermentation residues; however, the study did not take sizing into account (2016).

EXPERIMENTAL DESIGN

Five paper types with different sizings were treated using four treatment types—three different rigid polysaccharide gels and water. Treatments were applied directly to the paper samples or with an interleaving tissue. This resulted in 40 paper-treatment-application combinations. Half the paper samples for each treatment combination were artificially degraded (table 1).[1]

At each stage, visible and ultraviolet (UV) induced visible fluorescence light images were taken, and color, pH, and ionic conductivity were measured. The documentation methods described below were chosen since they are easily repeatable in most labs and easily compared to both past and future research.

Materials

Paper and sizings

The five paper types were selected to determine if age and/or sizing type were significant factors. Fiber analysis, using polarized light microscopy and micro-chemical spot testing, was done to confirm the characterization of the chosen paper samples and their sizings before experimentation (table 2). Each paper type was cut into 75 3 × 3 inch samples, which provided enough space to take all measurements while leaving an untreated 1/2 inch margin to prevent contamination during handling. Each sample received a unique number for record keeping.

Rigid gels & water

Each paper type was treated with one of three different rigid polysaccharide gels or water. Kelcogel and agarose were

Paper Type by Sizing	Name	Date	Fiber	Microchemical Testing
Whatman (unsized control)	Whatman Chromatography 1CHR	c. 2016	Pure cellulose cotton linters	Graff "C" Stain
Antique gelatin	handmade paper	pub. 1752, Paris	High cellulose bast	Graff "C" Stain; ninhydrin test
Modern gelatin	Canson Ingres	bought in 2020	Mixed wood, bast, and cotton	Graff "C" Stain; ninhydrin test
Alum rosin	LC Blue Book-keeper Test Book	1993	Highly purified pulp	Graff "C" Stain; aluminon test
Starch-based Alkyl ketene dimers (AKD)	Stonehenge Aqua Watercolor	bought in 2020	Highly fibrillated cotton	Graff "C" Stain; iodine/potassium test

Table 2. Paper Sample Identification

initially chosen because they are the most commonly used and researched rigid gels in the field. During this project's development, however, the lead author learned the vendor TALAS has been selling Ticagel by TIC Gums, Inc., as Kelcogel by CP Kelco since at least 2020 without clearly changing the online description and labeling. Since it is likely many practitioners have unknowingly used this different brand of gel, Ticagel was added to the experiment to compare its performance against Kelcogel. Water was included as a treatment to determine if reactions were gel specific or simply due to the introduction of water.

All three rigid gels were cast to ~3.0 mm thickness (Sullivan 2017, 45) and made per the standard literature preparation recommendations (table 3) (CP Kelco 2007; Iannuccelli & Sotgiu 2010; Isca 2014; Möller 2014; Sullivan 2017). The lowest typical concentration for each gel was chosen to maximize moisture release while still being representative of real-world use (Möller 2014, 8; Huber 2016; Sullivan, pers. comm., 2021). Each gel type was cut into 2 × 2 in. squares and centered to leave an untreated 1/2 in. margin on each paper sample. The water treatment was delivered via 2 × 2 in. Whatman chromatography papers soaked in DI water and blotted before application.

Interleaving

Interleaving is commonly used in the gel-bathing process of paper. To control for its potential effects on the gel-paper interactions, half of each paper-treatment combination (i.e., 5 out of 10 samples) were interleaved to determine if the degree of residue had a demonstrable effect on the resulting measurements and trends. HM-54 Usu-Gami Thinnest (9 g/m^2) tissue was selected to follow previously used protocols (Sullivan 2017; Muratore 2018). The tissue was cut into 3 × 3 in. squares and placed between the gel and paper sample during treatment.

Treatment Type	Percent	Recipe
Deionized water	N/A	deionized water
Ticagel L-6 Gellan Gum	2%	0.4 g/L calcium acetate in deionized water
CPKelco KELCOGEL LT100 Gellan Gum	2%	0.4 g/L calcium acetate in deionized water
Stellar Scientific Agarose LE	5%	deionized water

Table 3. Treatment Type Preparation

Treatment & artificial degradation procedure

Application of treatment type

To avoid contamination, all gels were handled with nitrile gloves. Interleaving was placed on half the paper samples—covering the entire paper sample before the moisture source was applied. After the rigid gel or water squares were placed, polyester film was laid on top of each sample set (fig. 1) to slow evaporation and defend against contaminants (Sullivan 2017). An acrylic block and light weights were then added to encourage uniform contact (Möller 2014, 45).

Treatment lasted 20 minutes to approximate a common treatment interval and ensure contact between gels and papers without being longer than proven necessary (Sullivan 2017, 43 and 46). Immediately after treatment, paper samples were placed under Hollytex, blotter, and weights until moved into a blotter stack to dry overnight.

Artificial degradation

Half the samples of each paper-treatment-application combination—200 paper samples in all—were artificially degraded, while the other half are being kept to serve as naturally-aged

Fig. 1. Detail of experiment setup highlighting gel application, using a rigid polyester jig, on paper samples directly and with interleaving.

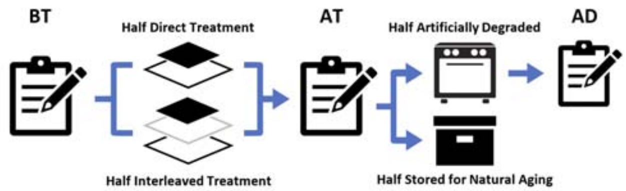

Fig. 2. Diagram of documentation stages.

samples for potential future testing. Samples designated for artificial degradation were sent to the Library of Congress, where they were hung by clips in a large oven and exposed to 80°C +/–2 and 65% RH +/–2% for 21 days. The author recognizes natural aging cannot be accurately predicted by artificial degradation (Porck 2000; Isca 2014, 41–42; Magee, pers. comm., 2020). However, the conditions used in this experiment were chosen to make the results most comparative to specific studies done on these materials (Warda 2007; Sullivan 2017; Muratore 2018). Artificial degradation has also been referred to as "accelerated" and "artificial aging" in the literature (Porck 2000).

Documentation procedure

At each stage—before treatment (BT), after treatment (AT), and after artificial degradation (AD)—samples were measured for color, pH, and ionic conductivity and imaged under visible and ultraviolet induced visible fluorescence (UV) light. Samples that were not artificially degraded were only measured and imaged BT and AT (fig. 2).

Color

The CIE L* a* b* color space, as defined by the International Commission on Illumination (CIE) (X-Rite Pantone 2016), was used to quantitatively track color change. Measurements were taken with an i1 X-Rite Pro Spectrophotometer and i1 Profiler software with the following settings: Delta E/ΔE 2000 (1:1:1), 2° observer angle, and D50 Illuminant. Delta E is a measurement of the total color difference between two samples (Datacolor 2013). Specifically, Delta E is the square root of the sum of the squared differences of each parameter (L*, a*, and b*). L* is the light-dark axis where higher values indicate lightening and lower values indicate darkening; a* is the red-green axis where higher values indicate a red shift and lower values indicate a green shift; b* is the yellow-blue axis where higher values indicate a yellow shift and lower values indicate a blue shift. According to X-rite (Customer Support, pers. comm., March 2021), Delta E values below 1 are not perceptible by human eyes; values between 1 and 2 are perceptible on close observation; and values between 2 and 10 are perceptible at a glance.

Measurements were taken on the same five testing sites on each paper sample at each treatment stage. Polyester film overlays were used to keep sample locations consistent (fig. 3). To avoid the printer's ink on the antique gelatin papers, an

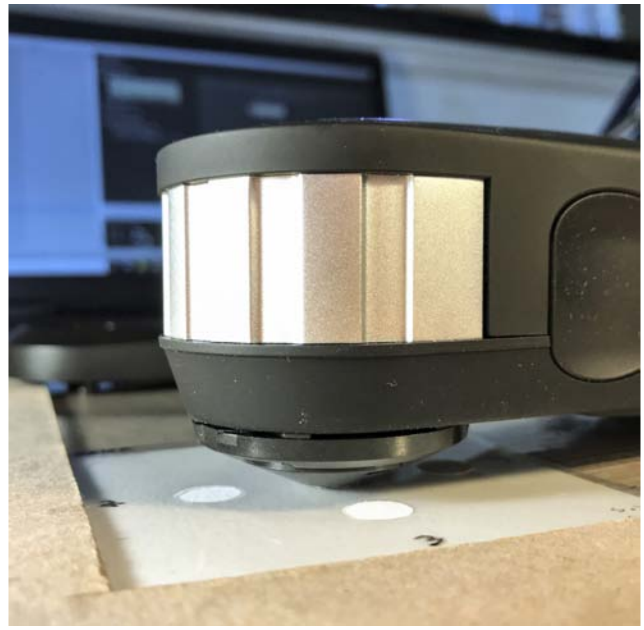

Fig. 3. Spectrophotometer and polyester overlay used to take color measurements of a paper sample.

overlay with an alphanumeric grid was used to identify and record testing sites (fig. 4). This adjustment made the testing sites less consistent and increased their variability when compared to the blank paper samples. Non-inked central and edge testing locations were identified for each antique gelatin paper sample during the planning stages to mitigate variability as much as possible.

All color measurements were taken before pH and conductivity measurements to prevent accidental change in color through proximity of gel blocks and water.

Fig. 4. Polyester film overlay with alphanumeric grid used to avoid the printer's ink when taking color measurements of the antique gelatin paper samples.

pH and conductivity measurements

Conductivity and pH measurements were taken to see if they shared patterns with the color data or other observations, because they are becoming more common characterization techniques in paper conservation. Measurements were taken with a Horiba Twin Conductivity meter and a Horiba LAQUAtwin pH meter, which was allowed to wet up for at least 1 hour prior to use. Before taking measurements, both meters were calibrated using the manufacturer's provided solutions. The pH meter was calibrated using the two-point method and was rinsed with distilled water between each measurement.[2]

pH and conductivity levels were collected with ~3 mm, 5% agarose square gel blocks that were placed on test sites for a minimum of 5 minutes. The gel blocks were rinsed and stored in DI water before use. According to Hughes, differences in concentration, dwell time, diameter, and thickness of gel plug has negligible effects on measurements, and the gel plug method is reliable for papers with a pH between 4.5 and 7—where most collections' materials tend to fall (2017, 65–66). See supplemental material for more details on the measurement process and meter troubleshooting.

During each treatment stage, measurements were taken from three new locations evenly distributed diagonally across a quadrant (fig. 5). To reduce test sites, each gel block was used to measure both pH and conductivity. As a result, conductivity was measured first to avoid the extraction of ions by the pH meter.

Imaging: Visible light and ultraviolet induced visible fluorescence

Photos were taken to capture changes in color and fluorescence of paper samples at different stages to qualitatively support the color data. They were taken with a digital single-lens reflux camera: a NIKON D700, with a 60 mm lens, set on a tripod. All raw images were processed in Adobe Camera Raw in best accordance with AIC standards (Warda et al. 2011). Visible light images were taken under LED 500, 5600K Flolights at approximately a 45° angle with the following camera settings: manual exposure, ISO 800, f-8 aperture, 1/60 seconds shutter speed, and preset white balance. UV light images were taken under long-wave UV (365 nm) lights at approximately a 45° angle, a PECA 918 filter, and the following camera settings: manual exposure, ISO 800, f-8 aperture, 1/8 second shutter speed, and Shade (8000 K) white balance.

The gel plugs used for pH and conductivity sampling were expected to cause changes that would be visible in the photo documentation. For this reason, photo documentation was conducted before taking any other measurements.

Fig. 5. Detail of agarose gel blocks on sample sites to take BT pH and conductivity measurements.

Data analysis

Across all groups and stages, 4760 color measurements (L★, a★, and b★), 2850 pH measurements, and 2850 conductivity measurements were recorded. Full datasets are available in the supplementary materials. The samples that underwent artificial degradation were used to determine if paper type, treatment type, and/or interleaving affected the response of color, pH, or conductivity to artificial degradation.

Data were analyzed in R (R Core Team 2020) using RStudio (RStudio Team 2018). The R packages tidyverse (Wickham et al. 2019), ggpubr (Kassambara 2020), gtsummary (Sjoberg et al. 2021), kableExtra (Zhu 2021), and colorspace (Zeileis et al. 2020) were used to tidy and visualize data.

L★, a★, and b★ values were used to calculate Delta E from BT to AT and BT to AD as a cumulative measure of color change for each paper sample at each of these time points. Linear models were used to assess the significance of interactions between paper sizing and gel treatment on color change AD. Specifically, analysis of variance was used to compare linear models with a response variable of Delta E from BT to AD as follows: intercept only model, paper type only model, paper type and gel treatment additive model, and paper type and gel treatment interactive model.

To determine how color changed AD, the average L★, a★, and b★ values were calculated for each paper type BT and AD and tested for statistically significant differences with Kruskal-Wallis ranked sum tests. L★, a★, and b★ values, as well as their corresponding colors BT and AD were plotted to get a visual sense of the amount of change in these parameters.

The averages and ranges of the pH and conductivity values were compared overall and analyzed for all paper sizing, gel, and interleaving combinations AD with linear models.

Response variables were modeled by combined gel and interleaving treatments for each paper type. Each treatment's test statistic was compared to that of the control group to identify significant effects of specific interleaving, gel, and paper combinations. Treatments with a p value less than 0.05 were considered to be significantly different from the control. The response variables were: Delta E from BT to AD, and L*, a*, b*, pH, and conductivity AD. Full tables of these results are available in the supplemental materials; statistically significant group averages and treatment effects are reported selectively below. When referenced in the results, SE indicates standard error, and p indicates the probability of the treatment group values being drawn from the control distribution.

RESULTS

Color change—Delta E

Comparison of the Delta E values between all treatment stages show the majority of color change for all paper and treatment types occurred AD (fig. 6). The AD color change was best modeled by including paper type, gel treatment, and their interaction terms as predictive variables, indicating interactions between paper sizing and gel treatments affect color change AD.

The unsized Whatman paper exhibits the least amount of color change AD; many samples have no perceptible change (Delta E < 1) and some show only slightly perceptible change (Delta E < 2) (fig. 7). All other paper types exhibit clearly perceptible color change (Delta E > 2) AD. The antique gelatin-sized papers show the most variation in color change AD; they range from slightly to clearly perceptible (0 < Delta E < 6). However, the antique gelatin samples also began with the most variable amount of discoloration BT.

*Color—L*a*b* (fig. 8)*

How paper color changed AD varied by paper type. The Whatman paper, which showed the least amount of color

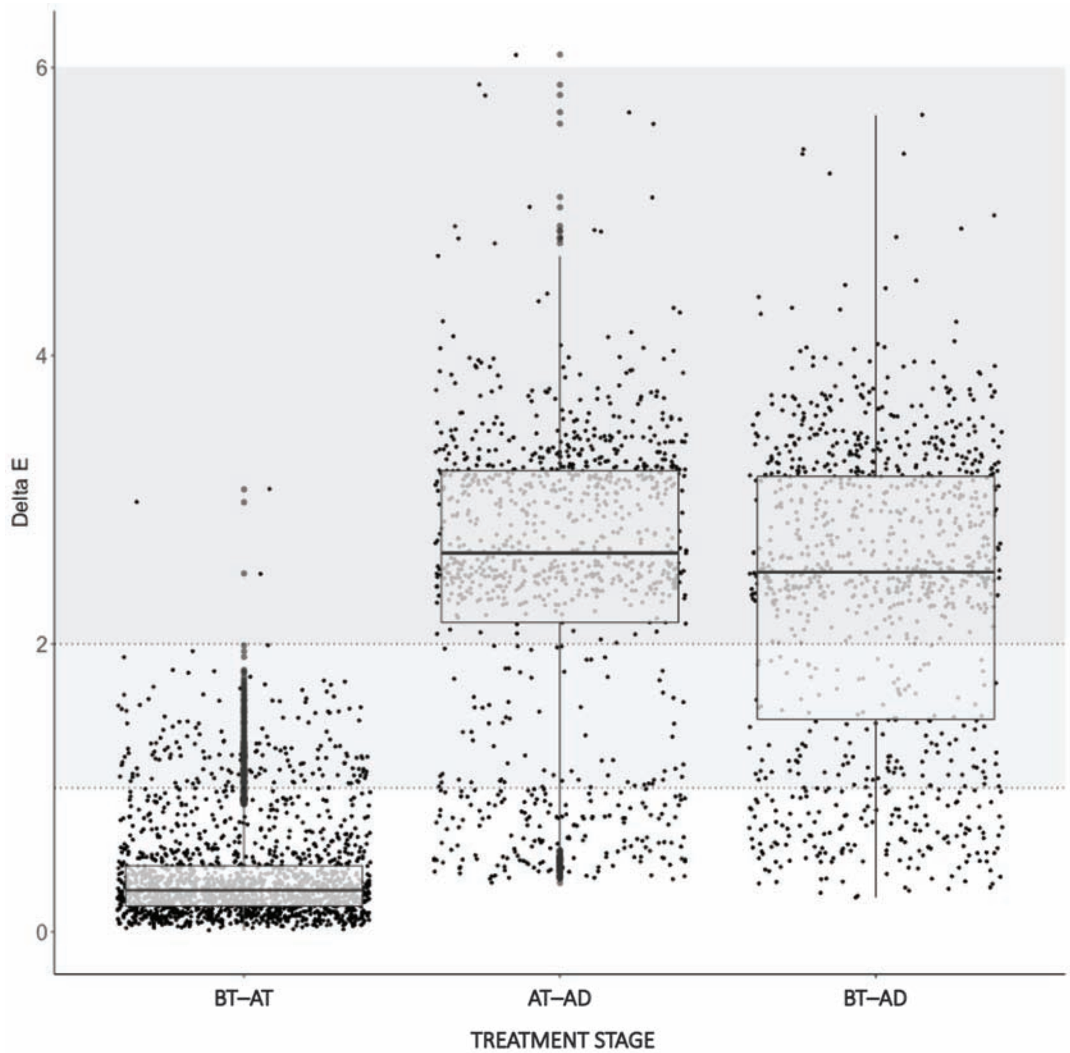

Fig. 6. Boxplots with underlying data points of Delta E for all samples from BT to AT, AT to AD, and BT-AD.

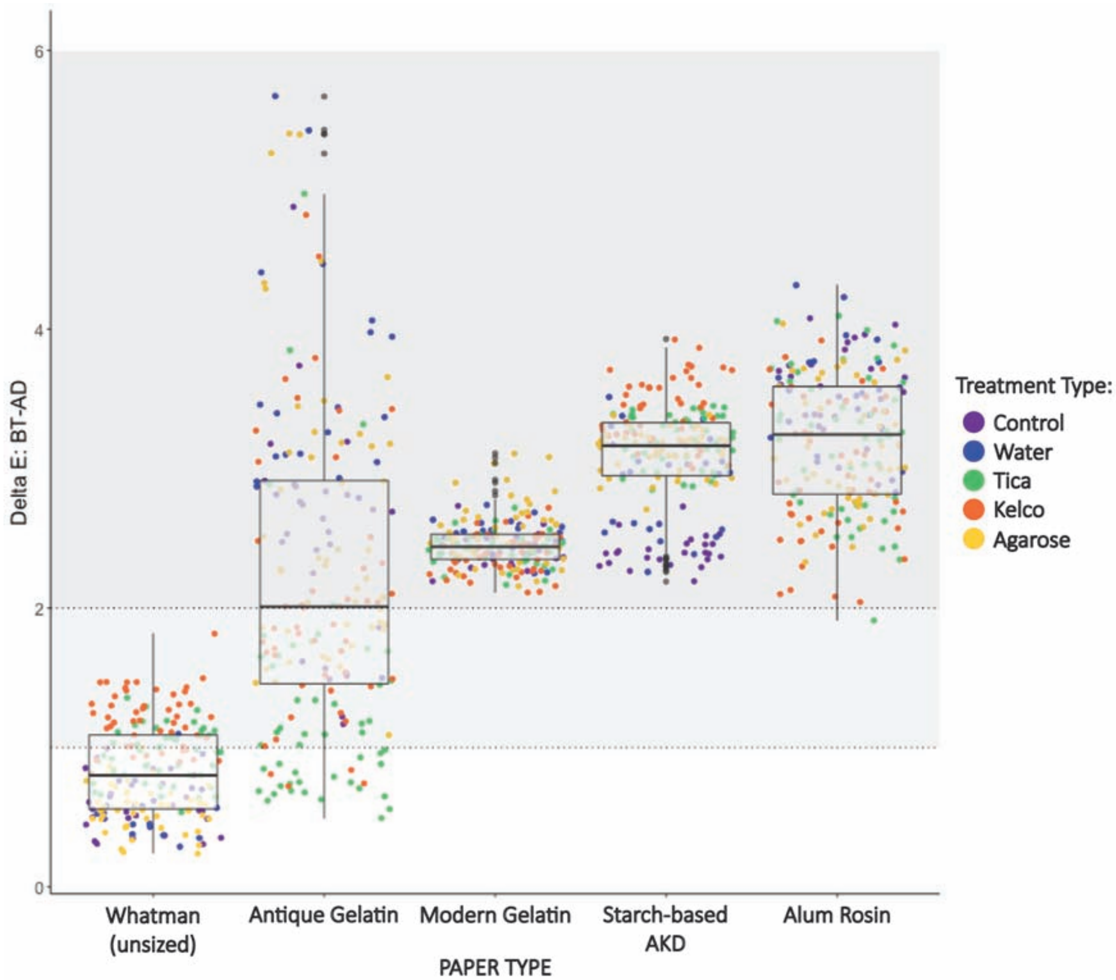

Fig. 7. Boxplots with underlying data points of Delta E from BT to AD for all samples, separated by paper type and colored by treatment type.

change overall, yellowed as indicated by increased b★ values AD. This was the only parameter that completely differentiated (no overlap in sample results) between BT and AD in Whatman samples. The antique gelatin-sized paper, which had the most variability in color change overall, got darker (lower L★), redder (higher a★), and yellower (higher b★) AD, though there was overlap BT and AD in all parameters. The modern gelatin-sized paper showed consistent perceptible color change AD. It got darker, greener (lower a★), and yellower, and the BT and AD samples were clearly differentiated by their a★ and b★ values. The paper sized with starch-based alkyl ketene dimer (AKD) showed two distinct paper sample groups by color BT. Both groups darkened and shifted yellow AD; however, they responded differently in the a★ parameter with Group 1 shifting red and Group 2 shifting green AD (G1 and G2 in fig. 8). The alum rosin paper darkened, reddened, and yellowed AD. Though some of the changes in the mean numerical value for each parameter were quite small, all differences between BT and AD were statistically significant for all paper types as tested with Kruskal Wallis test (kruskal.test() function in R) (fig. 9). The b★ parameters generally showed the greatest difference AD, which suggests yellowing occurs in all papers, as they degrade, regardless of sizing.

pH and conductivity

Generally, pH level and variability depends on the treatment and paper type (fig. 10). The naturally aged papers (antique gelatin and alum rosin) showed much less variability in pH AD, while the Whatman and new papers (modern gelatin and AKD) show a small change in variability AD. All treatments of the Whatman paper decreased in pH AT including the controls; however, AD the pH of all samples, except those treated with agarose and interleaved Kelcogel, rose to approximately BT levels. The naturally aged papers increased in pH AT with all three gels but remained unchanged after water treatment; they then decreased in pH AD—the antique gelatin paper's pH being similar to BT levels and the alum rosin's pH being notably lower than BT levels. The modern gelatin

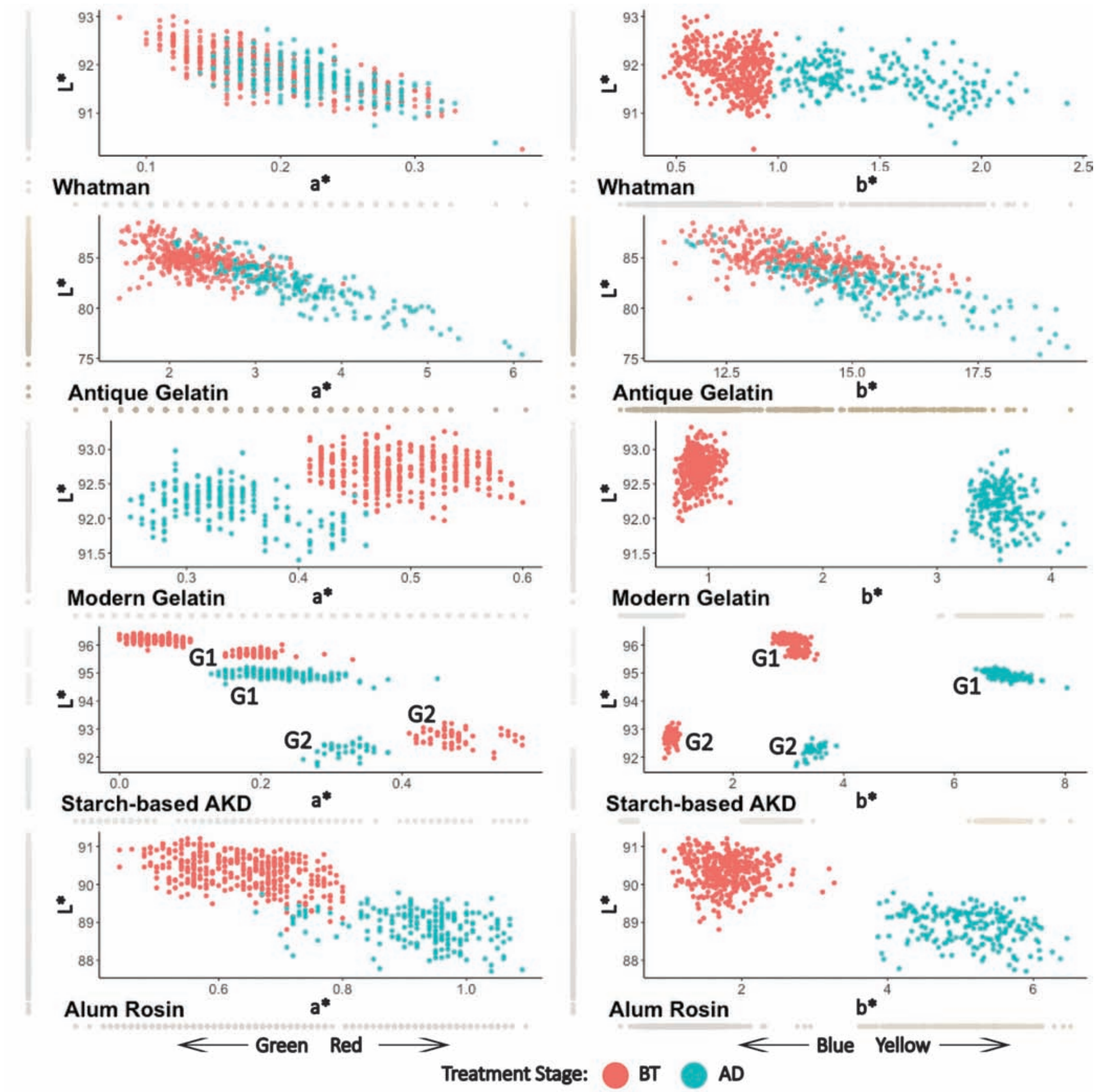

Fig. 8. Scatterplots of L★ a★ b★ values BT (blue) and AD (red) for each paper type. There are two plots for each paper type. The left-side plots have a★ on the x-axis and the right-side plots have b★ on the x-axis. All plots have L★ on the y-axis. Along the axes of each plot are the same sample points plotted in one dimension in their corresponding real-life colors where; the range along the y-axis shows their variation from dark to light, and their range along the x-axis shows their variation from green to red (a★, left side) or blue to yellow (b★, right side). Many changes are imperceptible, even when there is distinct clustering in the scatterplot.

paper showed very little change in pH at the different time points. The AKD-sized paper decreased in pH both AT and again AD.

For the antique gelatin-, modern gelatin-, and AKD-sized papers, conductivity became less variable and lower across time AT and AD (fig. 11). Regardless of time point, the antique gelatin-sized paper was most variable in conductivity, ranging from less than 0.1 mS/cm to just under 0.5 mS/cm, while the Whatman and modern gelatin-sized papers were the least variable. The conductivity of the Whatman paper

Paper sizing	Color parameter	BT mean	AD mean	p value (Kruskal-Wallis test)
Whatman	L*	91.92	91.70	2.4e-09
Whatman	a*	0.19	0.22	1.3e-15
Whatman	b*	0.77	1.49	5.8e-87
Antique Gelatin	L*	84.82	82.33	6.7e-43
Antique Gelatin	a*	2.32	3.48	2.3e-65
Antique Gelatin	b*	14.08	15.25	5.7e-21
Modern Gelatin	L*	92.71	92.20	5.1e-63
Modern Gelatin	a*	0.49	0.34	4.1e-82
Modern Gelatin	b*	0.91	3.55	5.7e-87
Starch-based AKD	L*	95.55	94.48	1.2e-48
Starch-based AKD	a*	0.14	0.24	4.6e-33
Starch-based AKD	b*	2.71	6.29	1.6e-87
Alum Rosin	L*	90.35	88.90	5.0e-84
Alum Rosin	a*	0.64	0.92	1.2e-81
Alum Rosin	b*	1.78	5.12	6.0e-87

Fig. 9. Mean L⋆ a⋆ b⋆ measurements for each paper type BT and AD, and the p values from each Kruskal-Wallis test for significant difference between the means of each measurement for each treatment stage.

was generally less than 0.1 mS/cm, and the conductivity of the modern gelatin-sized paper was generally right around 0.1 mS/cm. There were four individual outliers with conductivity greater than 0.5 mS/cm: two in the AKD samples BT, and two in the antique gelatin samples AD. In order to better visualize the majority of the data these outliers have been removed on figure 8.

Paper, treatment, application interactions AD

Whatman (unsized) paper (fig. 12)

The Whatman paper control samples had a Delta E value of 0.59 that corresponds to imperceptible color change. Both Ticagel and Kelcogel, interleaved and directly applied, showed significantly more color change than the control: all Ticagel treatments increased Delta E by 0.36 on average ($p \leq 5.3 \times 10^{-10}$), direct Kelcogel increased Delta E by 0.58 ($p < 2.2 \times 10^{-16}$), and interleaved Kelcogel increased Delta E by 0.65 ($p < 2.2 \times 10^{-16}$). This puts the Ticagel-treated samples on the verge of slightly perceptible color change and the Kelcogel-treated samples within the range of slightly perceptible color change.

The only type of color change for both the direct and interleaved Ticagel treatments occurred in the b⋆ parameter, which indicates these samples yellowed more than the controls. All three L⋆a⋆b⋆ parameters were different from controls for the direct and interleaved Kelcogel gel treatments; these samples yellowed, darkened, reddened, and reduced in pH more

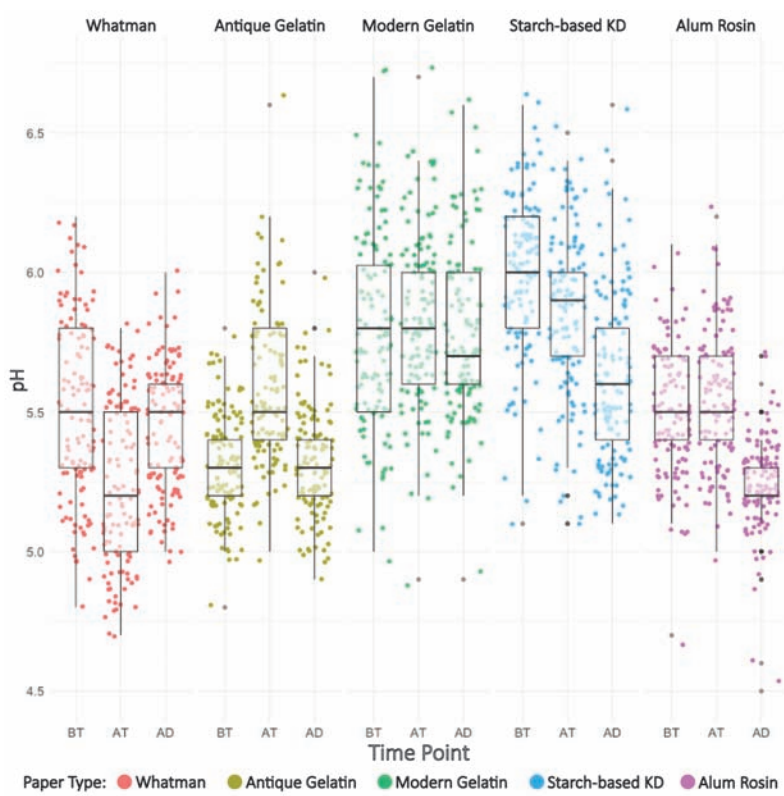

Fig. 10. Boxplots with underlying data points showing pH values at each time point separated and colored by paper type.

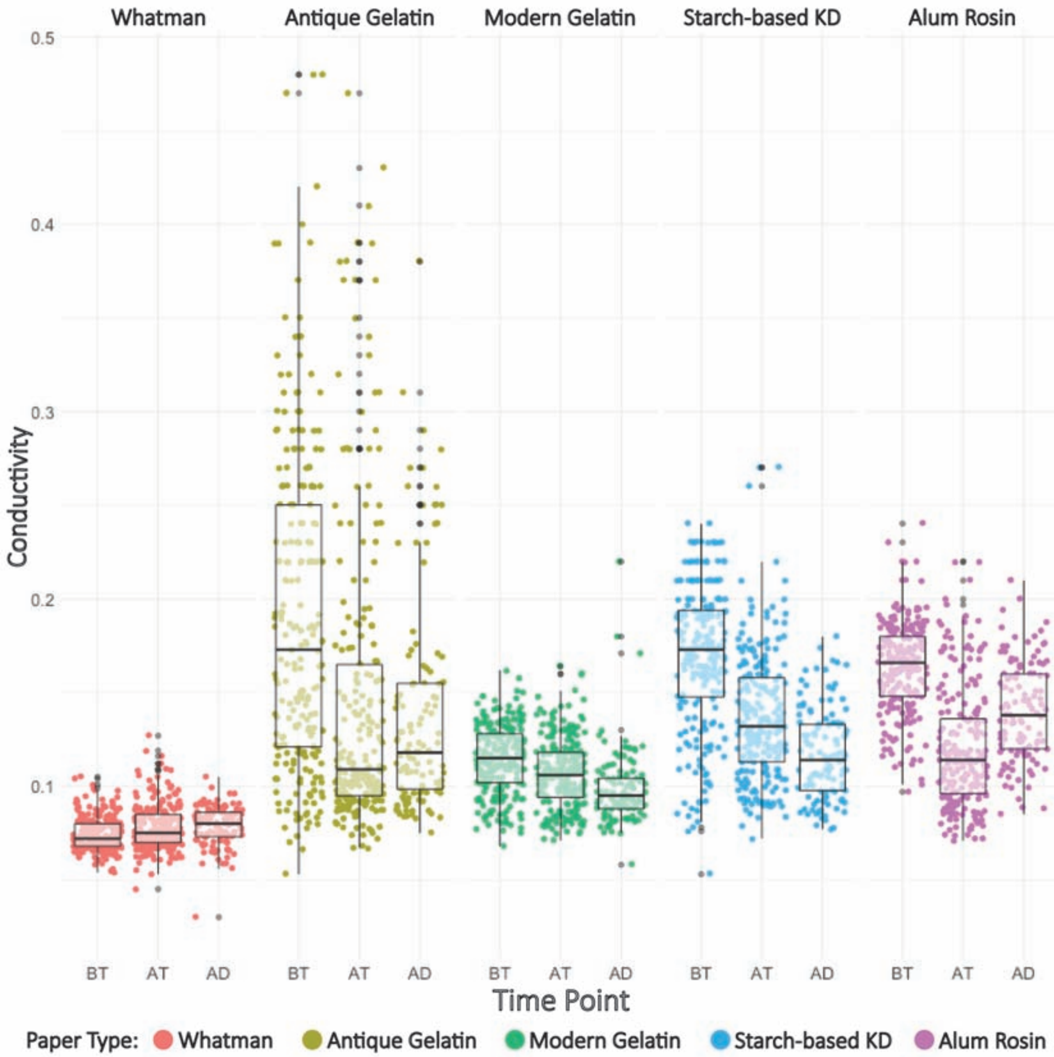

Fig. 11. Boxplots with underlying data points showing conductivity values at each time point separated and colored by paper type (with four outlying samples removed).

than the controls (Direct: –0.13, $p = 0.01$, Interleaved: –0.4, $p = 4.9 \times 10^{-13}$). The water treatment showed no significant difference as compared to the control in any of the color measurements, pH, or conductivity. The agarose gel treatments were not significantly different from the control in terms of Delta E, L*, or b*, but the interleaved agarose treatment showed less reddening (–0.02, $p = 0.04$) and had a lower pH (–0.40, $p = 4.9 \times 10^{-13}$) and conductivity (–0.009, $p = 0.01$). The direct agarose samples only had a reduced pH as compared to the control (–0.39, $p = 9.9 \times 10^{-13}$).

Antique gelatin-sized paper (fig. 13)

The antique gelatin-sized paper control samples had an average Delta E of 2.6, which corresponds to perceptible color change. The water-treated samples had a Delta E significantly higher than the controls (0.7; $p = 0.005$). All of the Ticagel-treated samples and the direct Kelcogel-treated samples had significantly lower Delta E values on average than the controls; they showed only slightly perceptible color change. The direct agarose samples also had a lower Delta E than the controls, while the interleaved agarose samples had a higher Delta E value.

Reduced Delta E values for the Ticagel-treated samples are due to reduced darkening, reddening, and yellowing as compared to the control, though the effect of direct Ticagel on reddening was only marginally significant. The interleaved Ticagel treatment had a much larger effect on average than the direct treatment on each of these measurements as evidenced by larger effect sizes and lower p values; however, there was more variation AD in the interleaved Ticagel-treated samples than the direct samples. Direct Kelcogel-treated samples and direct agarose-treated samples

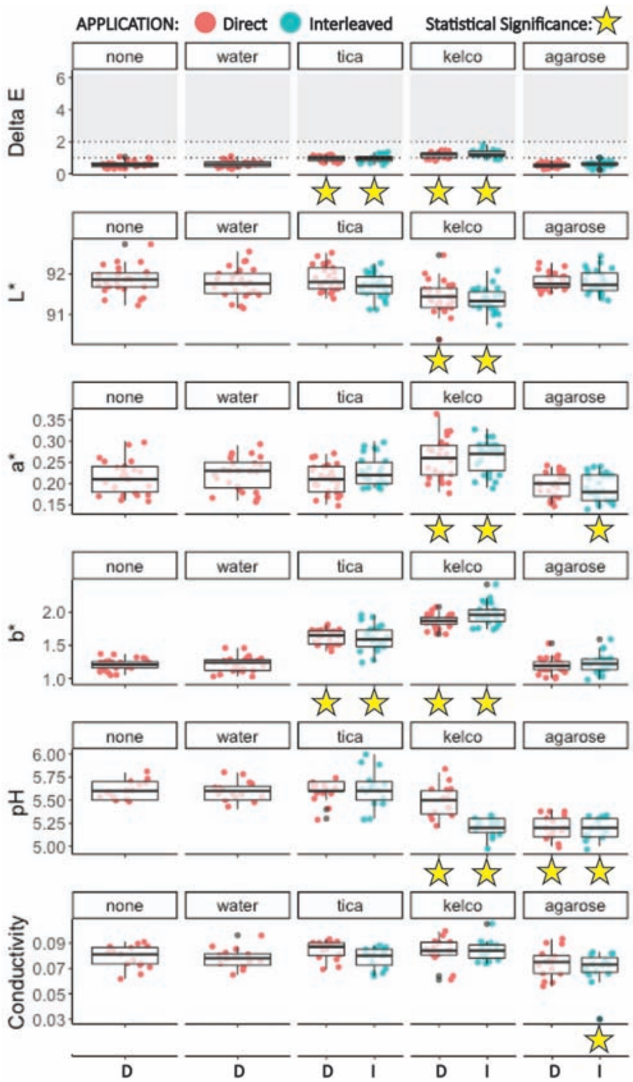

Fig. 12. Boxplots of Delta E, L★ a★ b★, pH, and conductivity AD for the Whatman paper samples, separated by gel treatment and colored by interleaving.

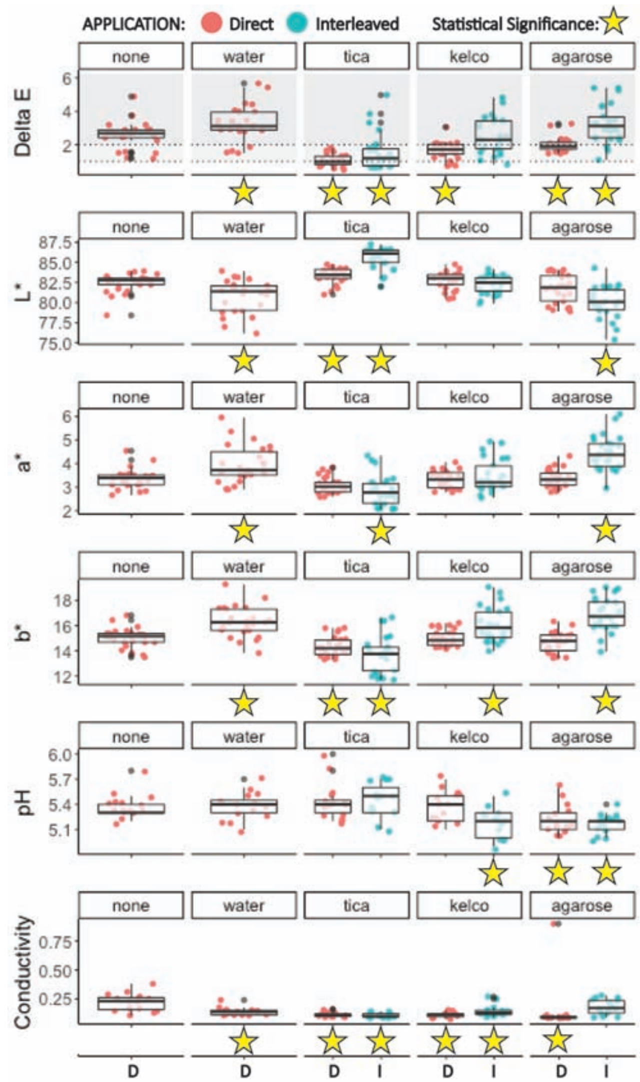

Fig. 13. Boxplots of Delta E, L★ a★ b★, pH, and conductivity AD for the antique gelatin paper samples, separated by gel treatment and colored by interleaving.

showed reduced color change overall as compared to the controls; however, none of the individual color measures were significantly different, which suggests these treatments did not impact any particular color parameter strongly but influenced each enough that their sum was significantly reduced. Though the interleaved Kelcogel treatment did not significantly change Delta E as compared to the control, it did significantly increase b★. The interleaved agarose samples significantly increased Delta E as compared to the controls and increased darkening, reddening, and yellowing. The water treatment showed no significant difference as compared to the control on any of the color measurements.

Both agarose treatments and the interleaved Kelcogel decreased pH, and all treatment types, except interleaved agarose, decreased the conductivity as compared to the controls.

Modern gelatin-sized paper (fig. 14)

The modern gelatin paper control samples showed perceptible color change with an average Delta E value of 2.41. The water treatment increased this average color change by 0.11 ($p = 0.009$), and the interleaved agarose treatment increased it by 0.20 ($p = 5.76 \times 10^{-6}$). None of the other treatments significantly impacted the mean color change; however, some of them did impact an individual color change parameter. All treatments increased yellowing as compared to the controls, and this increase was significant for all treatments except the interleaved Ticagel and Kelcogel. The change in a★ was more directionally variable between treatments; water decreased the reddening seen in the controls and both agarose treatments increased reddening. Both agarose treatments were also darker than the controls.

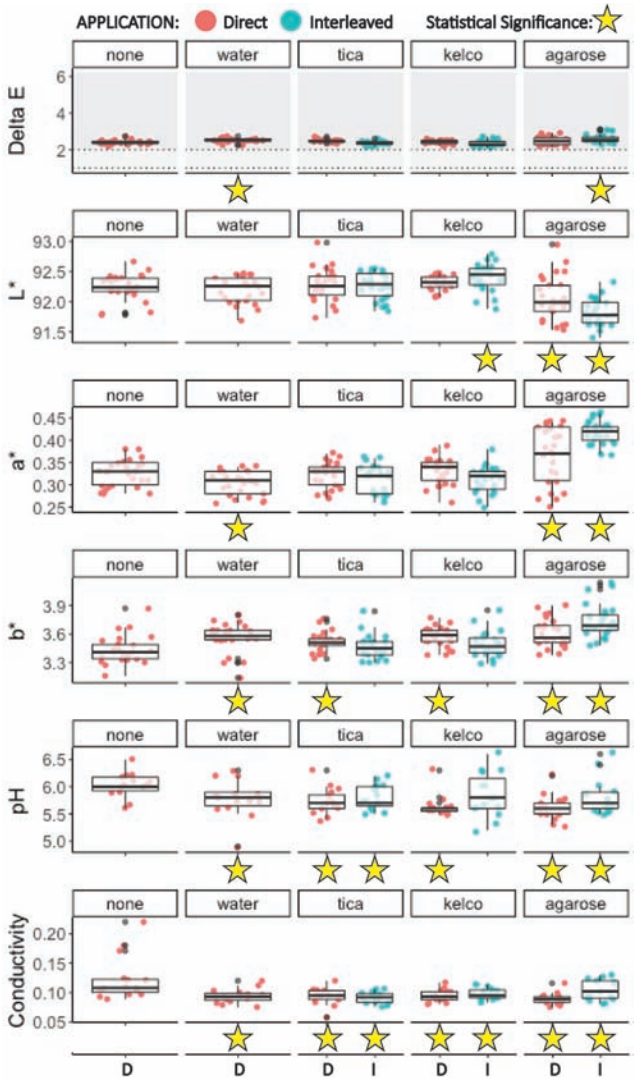

Fig. 14. Boxplots of Delta E, L* a* b*, pH, and conductivity AD for the modern gelatin paper samples, separated by gel treatment and colored by interleaving.

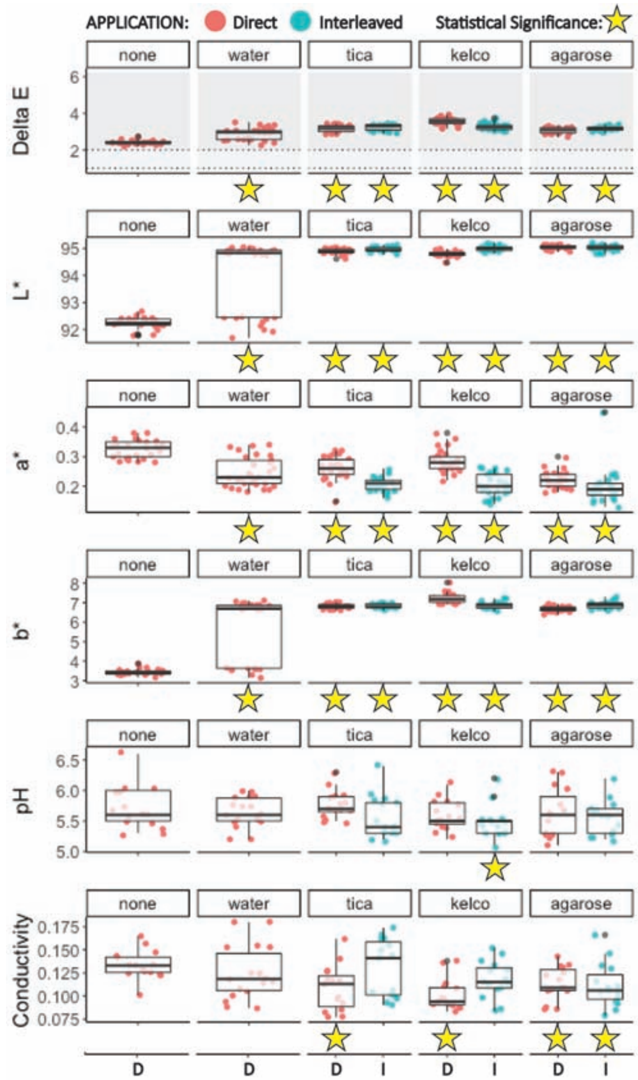

Fig. 15. Boxplots of Delta E, L* a* b*, pH, and conductivity AD for the AKD paper samples, separated by gel treatment and colored by interleaving.

The average pH of the controls AD was 6.03 mS/cm (SE = 0.08), and all treatment groups lowered this average by about 0.4 mS/cm except for the interleaved Kelcogel treatment that showed less of a decrease and was not statistically significant. Conductivity was also reduced by all treatments; direct agarose had the largest effect, and the interleaved agarose had the smallest effect.

Starch-based AKD-sized paper (fig. 15)

The AKD-sized paper control samples had an average Delta E of 2.41 (SE = 0.04), which was increased to various degrees by each treatment group. Direct Kelcogel showed the largest effect with an increase in Delta E of 1.13 as compared to the controls ($p < 2.0 \times 10^{-16}$). Water treatment showed the smallest effect with an increase of 0.48 as compared to the controls ($p = 2.63 \times 10^{-15}$). All treatments decreased darkening, decreased reddening, and increased yellowing as compared to the controls. Interleaved treatments decreased reddening more than the directly applied gels.

Interleaved Kelcogel-treated papers showed lowered pH as compared to the controls ($p = 0.03$). All direct gel and interleaved agarose treatments decreased conductivity as compared to the controls.

Alum-rosin–sized paper (fig. 16)

The alum rosin controls showed perceptible color change with an average Delta E value of 3.57 (SE = 0.07). All treatments lowered this Delta E value; however, that effect was only statistically significant for the direct gel treatments and the interleaved Kelcogel treatment. While the cumulative

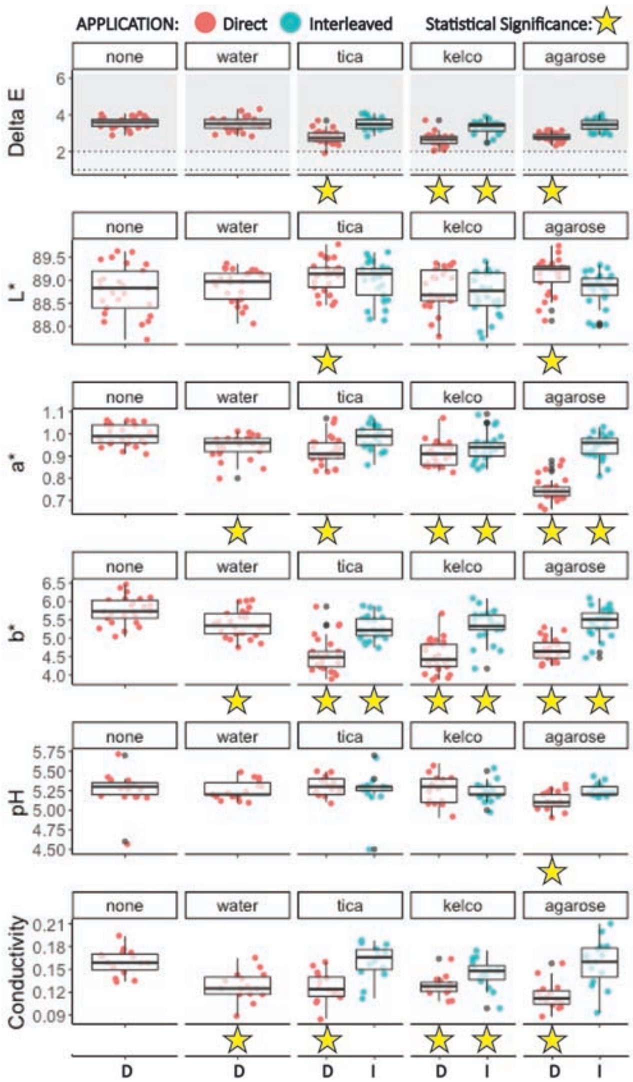

Fig. 16. Boxplots of Delta E, L* a* b*, pH, and conductivity AD for the alum rosin paper samples, separated by gel treatment and colored by interleaving.

color change was greatly reduced by the direct gel treatments, they still showed perceptible color change with average Delta E values greater than 2. All treatments reduced yellowing compared to the controls, with the direct gel treatments having the largest effect. Similarly, all treatments reduced reddening (with the exception of interleaved Ticagel whose effect was not statistically significant), and all direct gels had larger effects than their interleaved counterparts. Darkening was less affected by treatment; only direct Ticagel and agarose statistically differed from the control by 0.3 ($p = 0.01$).

The alum rosin controls had an average pH of 5.27 (SE = 0.04). The only treatment group with a significant effect was the direct agarose which reduced pH as compared to the controls by –0.14 ($p = 0.02$). Conductivity was 0.16 mS/cm on average (SE = 0.01) in the controls, and this was lowered by about 0.03 mS/cm – 0.04 mS/cm by all the direct gel and water treatments and lowered by 0.02 mS/cm by the interleaved Kelcogel ($p = 0.04$).

Visible and UV light photography

Additional photo documentation image files are available in the supplemental material. The images included in this paper were selected to highlight the most notable AD reactions discussed below.

Whatman (unsized) paper (fig. 17)

This paper type did not fluoresce under UV illumination BT. However, paper samples treated with Kelcogel and Ticagel had heightened fluorescence AT and AD that indicates residues were left behind. Interleaving did not prevent the Kelcogel residues from permeating the entire sample but did for the Ticagel treatment samples that exhibited an uneven fluorescent square in treatment areas. Interleaved and direct agarose and water treatments created some faintly fluorescent tidelines around treatment areas, which indicates less lateral flow and deposition of mobile materials. The pH and conductivity

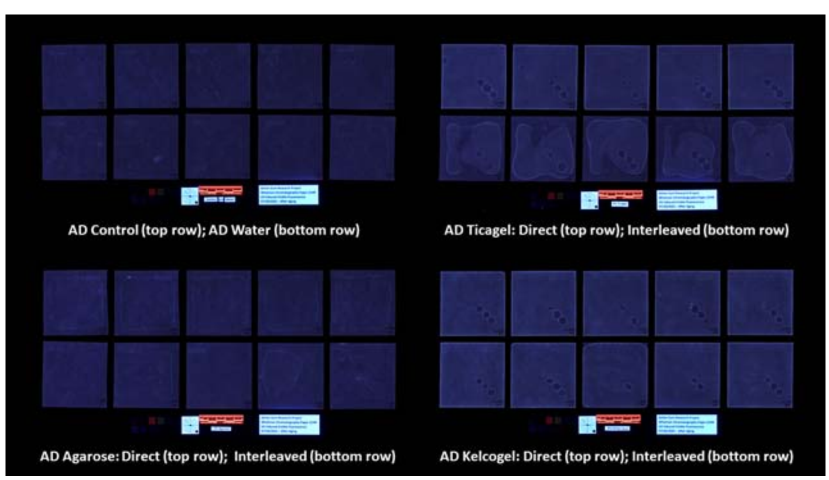

Fig. 17. Whatman paper samples after artificial degradation under UV light.

Fig. 18. Antique gelatin paper samples after artificial degradation under UV light.

sample sites taken AT are clearly visible as dark spots AD, which suggests agarose can pick up gellan gum residues. Though difficult to see in the visible light images, overall yellowing is visible with the naked eye around tidelines.

Antique gelatin-sized paper (fig. 18)

This paper type exhibited an uneven greenish-blue fluorescence BT. The directly treated samples have more distinct dark squares in the treatment area than the interleaved samples AT—an indication of greater, more uniform reduction of surface sizing. Treatment areas exposed to Ticagel are lighter than the areas exposed to Kelcogel or agarose. The treatment areas exposed to agarose remained distinctly dark AD; the treatment areas exposed to Kelcogel evened out AD, and the treatment areas exposed to Ticagel remained lighter than their discolored margins AD. This was consistent with color data showing Ticagel reduces darkness AT and mitigates darkening AD the most. Under visible light, most gel treatment areas appear lighter, but the interleaved samples exhibit uneven coloration. Tidelines are clearly visible under both UV and visible light in all gel-treated samples. Water treated samples showed a minor amount of darkening under UV light and a minor amount of visible tidelines under visible light AD.

Modern gelatin-sized paper

The manufacturer of this paper says it does not contain optical brighteners. However, it fluoresces a bright blue inconsistent with protein sizing. The bright blue fluorescence was present BT and persisted AT and AD with no obvious change. The fluorescence may be due to additives such as internal dyes and/or anti-biological agents, and the gelatin sizing may not be visible due to its source and young age. No change was apparent in treatment areas versus the margins of the samples with the naked eye under visible light AD.

AKD-sized paper (fig. 19)

This paper type exhibited a dull fluorescence under UV light BT. The water-treated samples showed no visible change AT or AD, but all three gel treatments caused darkening in

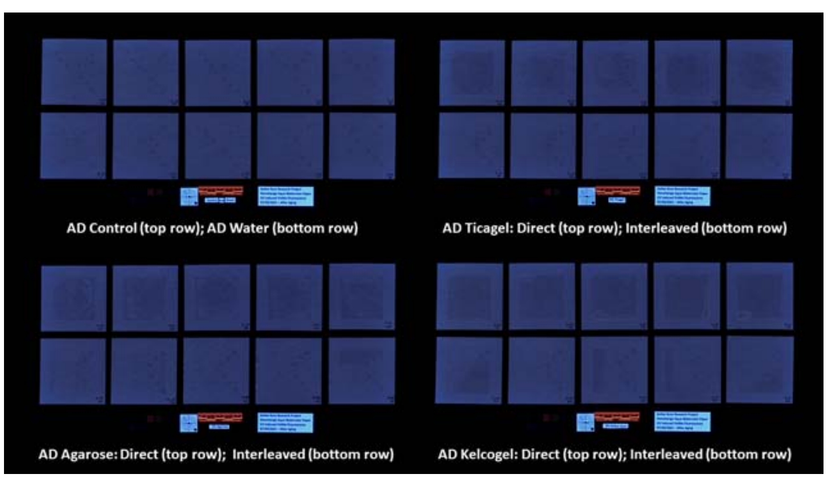

Fig. 19. AKD paper samples after artificial degradation under UV light.

treatment areas, indicating sizing material was removed. The direct application of the gel caused more distinct squares, while interleaving mitigated the sizing removal to varying degrees. In general, agarose and Ticagel removed slightly less sizing material than Kelcogel. Kelcogel also left more apparent green fluorescence along some tidelines. Like the Whatman paper, AT pH and conductivity sampling locations are clearly visible as small dark spots. No change was apparent in treatment areas versus the margins of the samples with the naked eye under visible light.

Alum-rosin–sized paper

This paper type fluoresced a pale blue under UV light BT. The direct agarose treatment caused a slight darkening, and the direct Ticagel and Kelcogel treatments caused a slight lightening AT and AD. The reaction in all cases is faint and is not visible in the interleaved samples. Based on the reactions of the other paper types, the difference in reactions may be the agarose removing sizing while both gellan gums leave behind a fluorescent residue. A slight lightening was apparent in direct Ticagel and Kelcogel treatment areas versus the margins of the samples with the naked eye under visible light AD.

DISCUSSION

All paper-treatment-application combinations experience the greatest degree of color change AD. The Whatman paper shows the least amount of color change while all other paper types exhibit clearly perceptible color change (fig. 7). Since the Whatman paper acts as an unsized comparison to the other paper types, this suggests sizing could lead to reactions that contribute to color change. The antique gelatin paper shows the greatest variability especially in its interleaved samples; this wide distribution is potentially due to the amount of degradation products already in the antique gelatin paper. Support for this theory can be seen in the alum rosin samples, the next oldest paper type, which display the second widest distribution and similar disparity between interleaved and direct application groups (i.e., its interleaved group performed similarly to the water-treated and control groups and less change was observed in the direct-contact samples).

The most notable Delta E result is the antique gelatin paper and Ticagel combination, which exhibits the least change out of all the treatments—meaning it mitigated darkening and discoloration more than other treatments. Kelcogel also mitigated the darkening and discoloration of this paper type but not to a statistically significant degree. Conversely, Kelcogel and Ticagel are the only treatments that caused any visible change in the Whatman paper. The effect of both gellan gums on these two paper types suggests that gellan gum as a material has a subtle effect that the other treatments do not. In addition, the consistency by which Ticagel and Kelcogel act similarly to each other in comparison to the other treatment types is encouraging for the previously untested Ticagel. It indicates the unknowing use of Ticagel for treatment of paper-based objects in the last few years is unlikely to have done any harm and may have even been beneficial. The most concerning trend in this study comes from the AKD paper. This paper type exhibited more statistically significant change than the controls with every treatment (with all three gels showing more change than water). This result suggests that this sizing type is the most vulnerable out of those tested.

Generally, conservators try to mitigate paper change over time; however, the paper's age affects what kind of changes are more or less desirable. Any change in new papers is undesirable, while certain kinds of changes are desirable when older papers are undergoing treatment. While Delta E measures the degree of change, it does not describe what kind of change has happened. For this, the individual L^*, a^*, and b^* color parameters were analyzed. The analysis found differently sized papers show different color changes AD depending on the use of interleaving and gel treatment. pH and conductivity were investigated to determine if there was a useful correlation. The pH and conductivity analysis showed these parameters have more consistent change AD; smaller differences between treatment types suggest color change cannot be completely explained by these parameters. A more detailed discussion of each paper's unique response is discussed below.

Whatman (unsized) paper

Whatman paper had the least amount of change of all paper types. Only Ticagel and Kelcogel are associated with change, and that change is only perceptible on close observation. The use of interleaving had no statistically significant impact on the color, pH, or conductivity measurements. However, it is clear in the UV images that interleaved Kelcogel treatments flowed further into the sample margins than the interleaved Ticagel treatments by the fluorescent residues. This suggests that interleaving mitigated lateral flow more with Ticagel than Kelcogel. The UV images also show both direct gellan gum treatments penetrated the entire paper sample and caused the entirety of the samples' surface to fluoresce strongly. Generally, for this paper type, all gel-interleaving combinations did not act much differently than the controls in the L^* and a^* parameters AT, though agarose seems to be better than the other gels at increasing light and reducing red when compared to the controls. The greatest effect AD was increased yellowing associated with the Kelcogel and Ticagel treatments. Out of the two, Kelcogel is associated with more yellowing than Ticagel in addition to increased darkening and reddening. Based on the fluorescence of these samples in the UV images, it seems likely that it is the gellan gum residues that are yellowing.

Curiously, all samples, including the controls, reduced in pH to a similar degree AT. The reduction of pH in the controls suggests that decreased pH cannot be considered a treatment-induced change for this paper type. However, the pH of interleaved Kelcogel and both interleaved and direct agarose-treated samples remained lowered AD, while direct Kelcogel and both interleaved and direct Ticagel samples performed similarly to the water and control samples. This supports the idea that agarose may be stripping beneficial sizing material away, and the residues left behind by both gellan gums can act as replacement sizing. Conductivity went up in all samples AD except agarose, which was the only treatment to mitigate that increase—perhaps due to its own nonionic quality, minimal residues, and effective removal of existing degradation products. This was the only paper type in which conductivity consistently increased AD, though the amount of change was very slight. The reason for this counterintuitive increase is unknown. Since Whatman paper has no sizing, these reactions may be representative of how the different treatment types interact with unsized papers: water-treated samples behave most like the controls while gel-treated samples have a greater effect on color, pH, and conductivity.

Antique gelatin-sized paper

Of all the paper types, the antique gelatin had the greatest data spread and the most variable amount of color change—ranging from imperceptible to easily perceptible. Water and interleaved agarose showed the most color change AD, and all interleaved application combinations caused more visible and variable change than direct application. Variability among interleaved samples may be due to the quantity of mobile materials, such as degradation products, resulting from 270 years of natural aging. Surprisingly, direct application versus interleaving of Ticagel and Kelcogel caused the least and second-to-least amount of change, respectively. UV imaging shows areas treated with Ticagel are lighter than the water, agarose, and control samples. In contrast, UV imaging reveals that agarose-treated areas remain the darkest. This could mean agarose is removing the most sizing and not depositing residues which would be consistent with the Whatman paper reactions. In this context, the authors postulate that gellan gum residues might be acting as a new "sizing," or protective barrier, rather than leaving the paper matrix stripped of its original sizing and susceptible to increased degradation. If true, this implies the effects of interleaving and gel choice can be used to tailor conservation treatments to suit the needs of an object. For example, to avoid causing areas of distinct change in the future, interleaving may be used to prevent over cleaning and/or gellan gums can be used to impart protective residues when performing spot treatment.

In general, gel treatments follow similar patterns for color, pH, and conductivity (lighter, greener, bluer, increased pH, and reduced conductivity AT; darker, redder, yellower, reduced pH, and reduced conductivity AD). However, Ticagel clearly performs best across all parameters and treatment stages, followed by Kelcogel, and then direct agarose. Interleaved agarose and water tend to perform most similarly to or worse than the controls.

Modern gelatin-sized paper

In direct contrast to the antique gelatin papers, the modern gelatin papers had the least data spread and the least treatment-specific color change across all gel and interleaving combinations. Color measurements identify the change as just above the perceptible threshold for all treatments and the controls AD, but it is difficult to see the differences in visible light and UV images. All treatment types followed the control pattern of getting lighter and greener but remaining unchanged in the b* parameter AT then getting darker, greener, and yellower AD. The most statistically significant differences between the controls and the treatment groups occurred in the a* parameter. This color change was observed both AT and AD, which suggests these treatments might have a greening effect on the paper. Since this is a new paper, any color change is undesirable. In a similar vein, the unchanged b* parameter after all treatment types (except agarose) may be considered the most desirable reaction for a new paper.

There is a slight reduction of pH and its variability with all direct treatment types AD. Interleaved treatments reduced in pH but had a higher variability than the direct applications. All treatment types had lower ionic conductivity AD in comparison to the controls, which show much greater variability AD. Treatment with gels results in similar conductivity AD as treatment with water—suggesting it may be the water and not the gels themselves having this effect. Similar to the antique gelatin, direct agarose shows a lowered conductivity (the lowest of all groups), while interleaved agarose shows a raised conductivity that is more similar to the control group. That direct agarose had the largest reduction in conductivity is not surprising, since it is supposed to be nonionic. In addition, the reduction seen with the interleaved treatments suggests that interleaving mitigates this effect in gelatin-sized papers. The agarose-treated samples show the most undesirable change across most parameters for a new paper.

AKD-sized paper

The AKD-sized papers saw a clearly perceptible color change AD as measured by Delta E and observed in the UV images. All treatments increased the amount of color change by reducing darkening, reducing reddening, and increased yellowing. While this was true of the water treatment as well as the gels, the water had less of an effect than the gels, which suggests the gels themselves are having a unique effect on the paper sizing. Reduced darkening and reddening are common color changes desired from a treatment; however, because this is a new paper, the increased yellowing and greater color change overall observed with the use of gel treatment is concerning. The interleaved and direct gel treatments had similar quantitative results, but the UV images show the gel effects are more uniform with direct contact than the interleaved treatments. Overall, treatment with gels seems to significantly remove the sizing of this paper compared to water, but removal may be mitigated with interleaving.

There were differences in the color measurements of this paper before any treatment, resulting in two visibly distinct groups when graphing the L*, a*, and b* values (fig. 8). The cause of this is unclear: perhaps this paper is not a uniform matrix, or, perhaps, some samples were accidentally measured on the underside, resulting in slightly different values. Where these groups responded differently was noted in the results section above.

While pH and conductivity are reduced with all treatments AT and AD, the interleaved Ticagel and Kelcogel mitigate conductivity reduction. This is potentially due to the calcium acetate in the gellan gum residues.

Alum-rosin–sized paper

The alum-rosin paper had the second greatest data spread, and the degree of color change was clearly perceptible for all treatment types AD. Though, when viewed cumulatively, each gel treatment resulted in less color change than the controls AD, the interleaved and direct gel treatments had different effects on color change. Direct gel treatments decreased the amount of reddening and yellowing much more than the interleaved gel treatments. The interleaved gel treatments still decreased the amount of reddening and yellowing but with a lesser effect that was not statistically significant AD. Since this result is similar to that of the AKD-sized paper, this suggests interleaving can decrease the efficacy of gels. This theory is supported by the UV images of most of the paper types, where distinct squares are perceptible in the direct gel treatment samples and not perceptible in the interleaved gel samples. Also of note: the direct Ticagel and Kelcogel treatment areas appear lighter in UV light compared to the agarose-treated areas which appear darker. Similar to the theory posited for the Whatman and antique gelatin papers, this may be due to the residues left by both gellan gums but not agarose.

Since the alum-rosin paper has already aged for three decades and is known for its poor aging qualities, it may be important to note that interleaving lessens the beneficial cleaning that results from direct gel application.

CONCLUSIONS

This research was initially carried out to determine if treating gelatin-sized papers with gellan gum causes unacceptable darkening or discoloration AD; its scope expanded to investigate the performance of Ticagel and evaluate the reactions between gel treatments and common paper sizings.

The experiment answers the initial question: contact between gellan gum and gelatin-sized papers does not result in a statistically significant degree of discoloration or darkening AD. On the contrary, the results suggest all three gels provide lasting benefits in regard to color change AT and AD. Furthermore, gellan gums perform better than Agarose—with Ticagel clearly performing better than the other gels overall and direct agarose seeming to strip paper of protective sizing. These conclusions are most clearly represented in the antique gelatin versus the modern gelatin paper, which is likely due to differences in their age and manufacture. However, there are several conclusions to draw across both gelatin-sized papers: water-treated samples acted most similarly to, or worse than, the controls; agarose treatment correlates with more extreme reactions; and both gellan gums struck the best balance between the type and degree of change with Ticagel performing better than Kelcogel across most parameters.

While there were some slight differences in their performance across all five paper types, Ticagel and Kelcogel performed similarly to such a degree that any paper treatments unknowingly performed with Ticagel due to mislabeling by Talas is likely negligible. In fact, Ticagel may have ultimately resulted in more beneficial treatments in certain cases.

In terms of reactions between gel treatments and common paper sizings, there are no inherently dangerous interactions between any of the paper types and a specific gel. However, trends and sensitivities do exist and are unique to each paper type (as exhibited by the already discussed gelatin-sized papers). Overall, interleaving mitigates the removal of sizing observed in direct treatment with rigid gels. While interleaving can act as a barrier to reduce negative gel effects on AKD-sized paper, it can also reduce the positive effects of gels on other papers. In the treatment of alum rosin paper, direct gel treatments mitigated undesirable color change to a greater extent than applications with interleaving, while interleaving mitigates over-cleaning in the sensitive AKD-sized papers. Finally, the Whatman paper provides an unsized comparison and illustrates the increased degree of lateral flow, yellowing, and increased conductivity levels of both gellan gums' residues in comparison to agarose and water.

One promising, though unexpected, observation was the detection of gellan gums residues and their potentially beneficial use in conservation. Even though they seem to yellow with age, gellan gum may be preferable over agarose to avoid differential aging in treated areas when performing spot treatments. Alternatively, if more uniform removal of aged sizing is desired or acceptable, such as during bathing, agarose can be used. Furthermore, knowing gellan gum residues impart some of their own qualities (such as conductivity) implies gel formulation can also be used to deliver beneficial components to the paper matrix. Finally, caution should be taken when sampling with agarose plugs, since they may permanently alter papers with certain sizing types to a greater degree than previously assumed.

Due to the size of the collected dataset and limitation in time, the ideas presented here should be understood as the authors' interpretations and theories resulting from an initial analysis. The authors hope this data will continue to be used by other researchers to advance the understanding of gel use in library and paper conservation.

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NOTES

1. Early in the development of this experiment, the water-treated sample set was initially viewed as a second type of control group to identify if reactions were due to water exposure vs. gel contact. From this viewpoint, the inclusion of unaged water-treated samples seemed redundant. In addition, the removal of these samples helped reduce the quantity of measurements required. During analysis, however, it became apparent that water could be viewed as both a control and treatment type. Unfortunately, this also means the artificially degraded water-treated samples will not have naturally aged counterparts available for future study.

2. Early in the experiment, the sensor in the pH meter failed. This was determined via consultation with HORIBA Instruments Inc. The failed sensor was discovered after taking the BT and AT measurements but before taking the AD measurements of the artificially degraded samples. All measurements of the non-artificially degraded samples and the AD measurements of the artificially degraded samples were taken with a new pH meter sensor. Analysis of the data shows no indications that the change in sensor affected the data or results—suggesting the sensor did not fail until after the BT and AT measurements were taken.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in *Arch: Northwestern University Institutional Repository* at https://doi.org/10.21985/n2-653y-1294.

All supplemental material listed below will be available via the above DOI:

- Raw data csv files and R analysis code
- Supplemental graphs
- Full bibliography
- Sources of Materials document
- Visible and UV photo documentation in PowerPoint
- Additional experimental design images and notes in PowerPoint
  - Paper type characterization
  - Summary of WUDPAC 2019 accelerated degradation experiment
  - Measurement taking process
  - pH and conductivity measuring process and meter troubleshooting

Conservation and Study of Simon Pokagon's Birch Bark Books

INTRODUCTION

While birch bark is more often found in museum collections, it is less common in libraries and archives. The need to learn more about the history and material technology of birch bark in bookmaking arose when the authors received damaged copies of Potawatomi author Simon Pokagon's birch bark books, *The Red Man's Greeting* and *The Red Man's Rebuke*, at the Weissman Preservation Center (WPC), Harvard Library, and the conservation lab at the University of Michigan (U-M) Library. Neither of the authors had treated birch bark before, although Kaye specializes in the conservation of ancient Egyptian papyrus at U-M and has worked on other lightly processed plant-based substrates. When the authors received these books to treat in their respective labs, they both had to think deeply about how to proceed. Before starting treatments, they needed to learn more about Simon Pokagon and the cultural significance of birch bark to the Anishinaabe culture. In this essay, the authors share their in-depth research into Simon Pokagon's birch bark books. Sjoblom and Kaye considered their roles as conservators in treating a text by an Indigenous author while learning about the materiality and use of birch bark. Both the tangible and intangible aspects of Pokagon's birch bark books were considered as a framework for conservation and preservation.

The research presented in this article relied heavily on experts in many areas. The authors are grateful to have learned from the work and knowledge of Anishinaabe scholars, artists, historians, scientists, and many more experts. The Anishinaabe (or *Neshnabék* in Potawatomi spelling, meaning "original people," referencing the Anishinaabe creation story) is a group of culturally related Indigenous peoples in the Great Lakes region of what is now called Canada and the United States[1] (Pokagon Band of Potawatomi, 2022, *History*). They include the Ojibwe, Odawa, and Potawatomi. The authors want to particularly highlight Dr. Blaire Morseau (Pokagon Band of Potawatomi) and artists Kelly Church (Gun Lake Band of Potawatomi/Odawa/Ojibwe) and Devan Kicknosway (Mohawk/Potawatomi). Dr. Morseau served as the first archivist for the Pokagon Band of Potawatomi Language and Culture Center. Her article in *Michigan History* magazine was one of the first resources both authors read and discusses the meaning of Pokagon's use of birch bark and the collection of his birch bark books in the Pokagon band archive. Kelly Church is a fifth-generation basket-maker and creator of birch bark bitings in Michigan. She teaches widely, speaks about threats to natural resources used by Indigenous artists, and exhibits her work globally. Devan Kicknosway is a quillwork artist and YouTuber whose videos provide viewers the chance to learn about his artistic process and how he harvests and makes use of birch bark for his work.

The authors also corresponded with representatives of the Pokagon Band of Potawatomi, experts on the Native American Graves Protection Repatriation Act (NAGPRA) at their respective institutions, and professors and students who use the collections. They also listened to talks and read papers related to the conservation of Indigenous items and reviewed specifications such as *Guidelines for Collaboration* from the Indian Arts Research Center (IARC) at the School for Advanced Research (SAR), *Protocols for Native American Archival Materials* from the First Archivist Circle, and resources from the Association of Tribal Archives, Libraries and Museums (ATALM). These resources provided a foundation for Sjoblom and Kaye to approach treatment, as neither had previously worked with Indigenous collections. They also helped the authors understand the broader context of working with Indigenous collections in library and archives, such as sovereign rights of Indigenous communities, issues with collecting and ownership in non-Native institutions, digital and physical collection access, intellectual property issues, and proper naming and cataloging information.

Through the process of conserving and studying Pokagon's books, the authors learned about the many diverse ways the books can, and have been, used and interpreted. One exciting opportunity that came out of this research is the chance to contribute a chapter on the materiality and conservation of the books to an upcoming book edited by Dr. Morseau and published by Michigan State University Press called: *As Sacred to Us: Simon Pokagon's Birch Bark Stories in Their Contexts*.

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

The book is geared towards an Indigenous Studies audience and will include transcriptions of Pokagon's birch bark books, as well as chapters by scholars, including members of the Pokagon Band, about linguistics, geology, and the printing and distribution of the books, highlighting the myriad topics relating to these birch bark books. Participating in this project helped Sjoblom and Kaye gain a deeper understanding of the context and use of the books and shows the importance of reciprocity when doing research.

SIMON POKAGON

Simon Pokagon was a citizen of the Pokagon Band of Potawatomi Indians, a federally recognized tribe in southwest Michigan and northern Indiana (fig. 1). He was born in 1830 near Bertrand, Michigan and died in 1899 in Hartford, Michigan. He was the third son of Potawatomi Chief Leopold Pokagon. Chief Leopold Pokagon was chief in the first half of the 19th century, serving as the head of a Potawatomi village in the St. Joseph River Valley in southwest Michigan. Details of his life are largely unknown, but he was likely born as Odawa or Ojibwe and raised by the Potawatomi. Unlike other bands of Potawatomi, the Pokagon Band avoided forced removal from Michigan by the Federal Government because of Chief Leopold's role in the 1833 Treaty of Chicago. Chief Leopold separated his community from the rest of the Potawatomi by upholding strict temperance and emphasized the band's conversion to Catholicism to negotiate an amendment to the treaty, allowing the Pokagon Band to remain in Michigan (Low 2016, 29). Some Potawatomi were permitted to return to their land in Forest County, Wisconsin and in a few other areas in Michigan, but the majority were forced to leave the Midwest, with some fleeing to Canada and Mexico. With the Indian Removal Act signed into law by President Andrew Jackson in 1830, those who remained in villages in Indiana and Illinois were forcibly moved west in what is known as the "Trail of Death." Their descendants now live in Kansas (Prairie Band) and Oklahoma (Citizen Band) (Low 2016, 30). Although the Pokagon Band applied for federal recognition after the Reorganization Act of 1934, it wasn't until 1994 that their federally recognized status was reaffirmed by Congress (Pokagon Band of Potawatomi 2022, *History*).

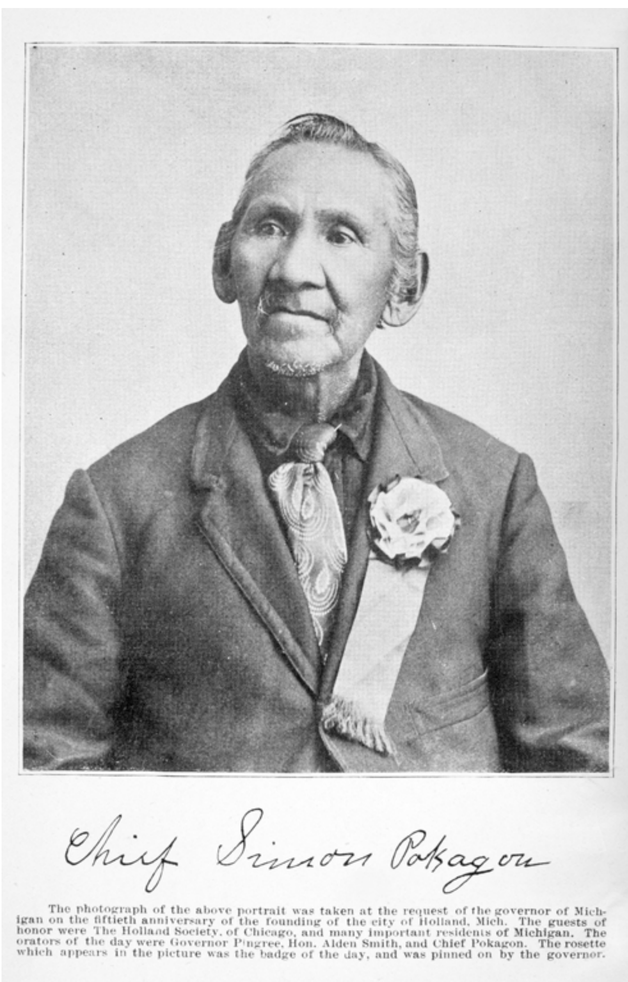


Fig. 1. Portrait of Simon Pokagon in *O-gi-maw-kwe Mit-i-gwa-ki, Queen of the Woods*, Simon Pokagon, 1899 (Special Collections Research Center, University of Michigan Library).

Simon Pokagon was an activist for Indigenous rights who fought for treaty payment for the Pokagon Band, eventually obtaining partial payment. To collect payment due to the tribe from the cessions of the 1833 Treaty of Chicago, Pokagon visited President Abraham Lincoln twice and met with President Ulysses S. Grant after the Civil War (Low 2016, 41). Yet he was also criticized for his questionable business practices, selling off the Band's interest in Chicago lakefront property to non-Native real estate speculators, with no authority to do so (Low 2016, 76). He is often described as being caught between two worlds, as he assimilated with the settler-colonial population around him, yet held strong to his own heritage and culture. His writings are interpreted as promoting reconciliation between the two races, rather than continued efforts to "civilize" Indigenous Americans out of existence (Cushing Davis 2015, 46). When he was not writing, Pokagon spent much of his time in tribal politics. By the 1890s he was no longer a leader of the Pokagon Band but still called himself the "chief" (Low 2016, 74). Pokagon Band member and scholar Dr. John Low (2016) speaks to this dichotomy when discussing Simon Pokagon's novel, *O-gi-maw-kwe Mit-i-gwa-ki, Queen of the Woods*:

> *Holding history in my hands, a portal to a shared past, time speaks to me through this book—its leaves, like worn and delicate sheets of birch bark—its talking pages pass on traditions as I turn them, as I fold the covers in to keep safe the lived experiences of then and now. This small book, a treasure, a memorial to my ancestors, a monument to the resiliency of a people, a tribe—ironically, unexpectedly, and eloquently,*

> *written by a man despised by some of his own people, yet embraced by the wealthy of his day. This man insinuated himself and his work into the high culture of America and there recorded our survival. (52)*

Due to the Potawatomi's distinct public presence as Indigenous Americans within the city of Chicago, Simon Pokagon played a visible part in the World's Columbian Exposition held in the city in 1893. This world's fair was held to commemorate the 400th anniversary of Columbus arriving in the Americas and the perceived development of the country. He was the honorary umpire of a lacrosse game where the Pokagon Potawatomi used their athletic traditions to assert their presence in the city (Low 2016, 142). He also built a birch bark tipi/wigwam at the Exposition, which was later moved to his home in Hartford, Michigan and after his death used by his publisher C.H. Engle as a tourist attraction (Low 2016, 168). Seen as a celebrity in Chicago, he was a featured "Chicago Day" speaker at the Exposition, where he spoke out against the oppression of Indigenous people and culture. It was for this event that he wrote and sold *The Red Man's Rebuke*, which was soon retitled *The Red Man's Greeting*, rebuking the celebration of colonization and asserting the continued Native presence in the area. This book was also featured on the fairgrounds at the Michigan State Exposition Building, becoming a highly sought item by book dealers and antique shop owners in Southwestern Michigan from the very start (Low 2016, 46).

Pokagon had a successful writing career and published many books and essays with the help of his publisher, C.H. Engle. Engle was a central figure in the white settler-colonial community and is frequently referred to as Pokagon's friend and attorney. Pokagon's most well-known work is the semi-autobiographical novel, *O-gi-maw-kwe Mit-i-gwa-ki, Queen of the Woods* (1899), which was also turned into a stage play. Five of his books were printed on birch bark: *The Pottawatamie Book of Genesis: Legend of the Creation of Man* (1901), *Algonquin Legends of Paw Paw Lake* (1901), *Algonquin Legends of South Haven* (1900), *The Red Man's Rebuke* (1893), and *The Red Man's Greeting* (1893). His work is important for its use of Potawatomi, Odawa, and Ojibwe language and holds a significant place in Indigenous book history for his ability to tell Indigenous narratives using his own language, but successfully marketed to a non-Native audience.

Pokagon's birch bark books are all small and short in length, 10 to 14 pages. The horizontally oriented *Rebuke* and *Greeting* are roughly 3 × 5 inches and only about 1/8″ thick (approximately 75 × 126 × 3 mm). His vertically oriented works on birch bark, such as *The Algonquin Legends of Paw Paw Lake* and *Pottawattamie Book of Genesis* are also tiny, at 84 × 60 × 2 mm and 94 × 65 × 2 mm respectively. All of Pokagon's birch bark books are oversewn with ribbon through three punched holes on the left edge. The pages vary in thickness, color, and natural aspects. They are relief printed in black ink, with text and illustrations throughout. Pokagon's publisher, Engle, had access to the printing plant at the *Hartford Day Spring* newspaper, which is where Pokagon's books were letterpress printed. The illustrations in the books appear to be wood engravings that were turned into stereotyped plates. Recent research by Dr. Kelly Wisecup to be published in *As Sacred to Us* provides new information on the printing, chronology, and differences between copies of these books. In examining the books, the printed impression varied greatly due to the natural variations in the page, such as knots and uneven laminations (fig. 2). The white powdery substance on the surface of the birch bark, called betulin, also reduced the legibility of some text. These observations highlight the challenges in printing on an uneven, water resistant, natural material, such as birch bark.

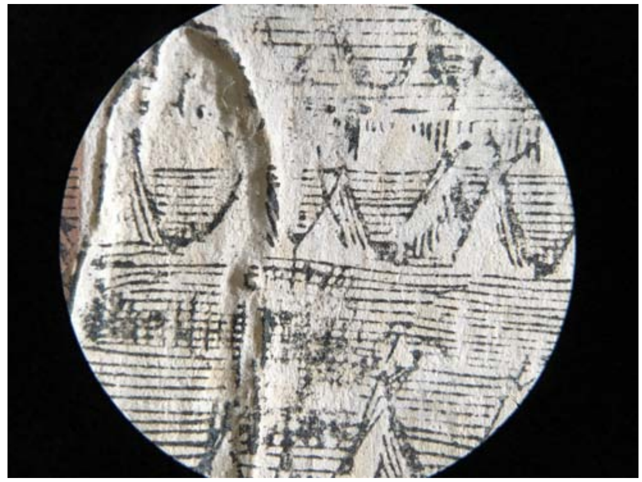


Fig. 2. Photomacrograph (15x magnification) of *The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University). An example of printing where the text sits only on the highest points due to the uneven surface.

BIRCH BARK

Pokagon (1893) explained why he chose to use birch bark for his book in *The Red Man's Rebuke* at the very start of his text. He states:

> *My object in publishing The Red Man's Rebuke on the bark of the white birch tree is out of loyalty to my own people, and gratitude to the Great Spirit, who in his wisdom provided for our use for untold generations, this most remarkable tree with manifold bark used by us instead of paper, being of greater value to us, as it could not be injured by sun or water (By The Author).*

Paper birch, or wigwas in the Potawatomi language, is found in the sub-boreal forests of Northern United States and Canada (Moser et al. 2015, 1). It is the periderm layer of the

Fig. 3. Photomacrographs (15x magnification) in *The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University); from left to right: betulin, lenticels (inner), lenticel (outer).

outer bark of the tree and has a laminar structure caused by seasonal growth (Maitland 2016, 51). Seasonal growth also leads to the color differences in the laminates, with cells formed in the later spring to early summer that are broad in the radial dimension and light in color due to a high betulin content; and the cells formed in the later, colder season that are narrow in the radial dimension and dark in color due to tannins and other phenolics (Tse et al. 2018, 424). Betulin is a white powdery triterpene found on the surface of the bark that is antifungal and, along with the natural oils in birch bark, means that birch bark is incredibly resistant to insects, biodeterioration, and water (ibid). The layers of the bark are held together with pectin, as well as the horizontal streaks in the bark called lenticels, spongy weak areas that allow gas exchange between inner and outer tissue (Krueger 2008, 30) (fig. 3).

In the late 19th century, when the books were made, much of Michigan and the Great Lakes Region were ceded. Harvesting could occur on private land, and treaty rights may have allowed the Pokagon Band access to public land as well (*Great Lakes Fish and Wildlife Commission [GLIFWC], [N.d.]*). In the early 19th century, the Pokagon Band was in Bertrand Township in southwest Michigan (Pokagon Band of Potawatomi, *History*). However, the Treaty of 1833 required the Pokagon band, led by Leopold Pokagon in 1838, to relocate north to the L'Arbre Croche region (present day Emmet County, Michigan) with the Odawa. Further treaties between the Odawa, Ojibwe, and the United States government led to the cessation of this land, and Leopold and his band returned to southwestern Michigan, purchasing land near present day Dowagiac, in Van Buren County, using annuities from land treaties. Although once more widespread, birch remains in southwestern Michigan but is now more concentrated in the most northern regions. Kelly Church, who lives and works in Michigan, noted that although birch is more prominent in northern Michigan, she believes that there would have been large stands of birch in southwestern Michigan before the area was cleared for housing development (Church, pers. comm.). This is seen in the use of birch for summer lodges, canoes, baskets, and scrolls in the area, showing that the material was available and widely used (*ibid*). It is important to note that Native artists' ability to obtain materials such as birch bark is impacted by restricted land access and climate change, risking the loss of generational knowledge.

To understand the material and have samples to work with, both authors attempted to harvest birch bark (fig. 4).

Fig. 4. Sjoblom harvesting birch bark from fallen trees in Oakland, Maine in 2020.

This was before speaking to experts, and it became very clear just how much knowledge and skill goes into harvesting birch bark successfully. Sjoblom harvested from dead trees in autumn in central Maine in 2020, and although she was able to peel some thinner sheets, she struggled to achieve sheets the size of the book pages without splits. She experimented with heat and soaking to see if this helped separate the layers, but with little success.

Pokagon (1898) described how he understood the way birch trees grow and how they can provide material for those who work with it:

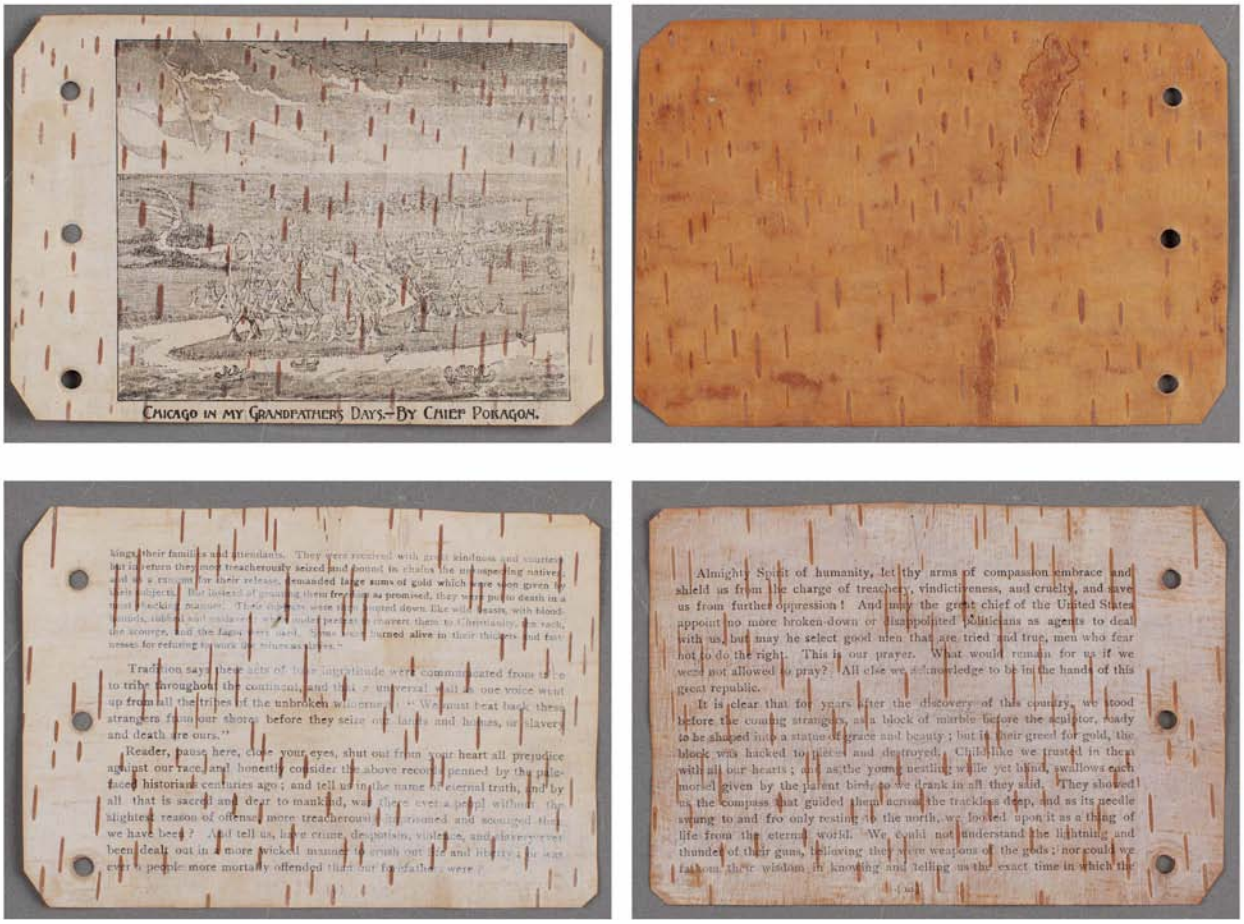
> *Nature has richly provided this particular tree with two grades of bark: an inner gray bark, which runs with the grain of the wood, and an outer bark, the grain of which runs round the tree at right angles to the inside gray bark. During each year a layer of thin, tough, paper-like bark is found around the outside of the inner gray bark and under the previous year's growth. These sheets, being formed annually, cause the bark in time to become manifold; and as the tree increases in size they must grow and expand so as to correspond with the increased diameter of the tree. During springtime the various years' growth of bark can be separated and wound off in single, double, or triple sheets, so as to suit the different kinds of work desired. For some cause these sheets of bark of different years' growth vary in hues of red, white and gold. (540)*

Understanding the structure of birch bark provided a vocabulary to describe the material but not an understanding of its cultural significance and what this indicated about the creation of the books. The chance to speak with Kicknosway and Church in 2021 provided information that was key to understanding the books based on their skill and generational knowledge. Both artists are dedicated educators who share their knowledge in many settings. However, out of respect for their traditional knowledge, in this article the authors focus on understanding birch bark harvesting in relation to Pokagon's books, rather than an effort to record the process more broadly. This information can be found in interviews, blog posts, and recordings of Church and Kicknosway, as well as other Anishinaabe artists, in their own voices. The authors provide a closer examination of the birch bark books in relation to the artist interviews in *As Sacred to Us.*

Devan Kicknosway's YouTube video, "How I Harvest Birch Bark," is an excellent resource for observing the process in detail. Most often, birch bark is harvested from live trees and, if done without damaging the cambium, does not harm the tree and the bark will eventually regrow (Emery et al. 2014, 208; Kicknosway 2020). However, even if properly harvested, the new bark growth will be permanently changed (Geniusz 2009, 183). To harvest the bark, Kicknosway makes a long vertical and two small horizontal cuts in the outer bark (like a serif capital letter I) and gently removes the bark (Kicknosway 2020). If a larger piece of multilayered bark is harvested at the correct time, the harvested piece of bark can be successfully peeled into even thinner layers later. Both artists explain that properly harvested and stored birch bark can be preserved for many years and retains its desired working qualities (Church and Kicknosway, pers. comm.).

From the artist interviews it became clear that the time of year directly influences the physical qualities of the final product. When lighter-colored, thin, and flexible bark is needed, such as for quillwork and birch bark bitings, bark harvested on the warmest days in the summer is used, which is referred to as summer bark. Winter bark, harvested on the coldest days, is darker because it is rich in tannins. This bark is used for etchings and is stiffer and thicker. Both artists explained that summer bark is easily peeled into thin layers, but this can be more difficult to accomplish with winter bark. Church uses summer bark peeled into single layers for her birch bark bitings, which have a similar quality to the thinner pages seen in Pokagon's books. In examining the books, the authors found that there was significant variation in color from white to orange, as well as thickness from single to multiple layers (fig. 5). Therefore, they were able to identify that both summer and winter bark were used.

Many varying characteristics were observed when examining the books, and no two pages are the same. Some pages have knots, remnants of inner bark, and sap accretions, and the size and direction of the lenticels varies. Both artists noted that they consider all these things when selecting the trees they harvest because of the aesthetic and mechanical impact it has on their work. The artist interviews provided key information used to interpret the differences seen in the books and helped explain what this suggests about how the bark was collected for printing *The Red Man's Rebuke/Greeting.* At this time no records have been found about who harvested and prepared the bark for Pokagon's books. Pokagon included images in the back of his novel, *O-gi-maw-kwe Mit-i-gwa-ki, Queen of the Woods*, showing items made of birch bark and the women who created this work in his town (fig. 6). At the time there was increasing demand by museums and tourists for Indigenous handicrafts, supporting the economic interests of the Michigan Potawatomi (Cushing Davis 2015, 45). This may indicate that they, or someone in the direct family, were involved in harvesting and preparing the bark for Pokagon's books. It supports the theory that the bark came from Potawatomi artists, or those in the Pokagon Band. The presence of both summer and winter bark in a single book suggests that Pokagon Band artists had a collection of birch bark on hand for various uses, which may have been used for the printing of the books. With the growing demand for the books, supplies may have been quickly depleted, leading to less pristine birch bark being used. Without further examination of more copies of the books, and without supplementary information on the time of purchase and provenance, it is not possible to come to a definitive conclusion as to where the birch bark was harvested and sourced.



kings, their families and attendants. They were received with great kindness and courtesy, but in return they most treacherously seized and bound in chains the unsuspecting natives, and as a ransom for their release, demanded large sums of gold which were soon given by their subjects. But instead of granting them freedom as promised, they were put to death in a most shocking manner. Their subjects were then hunted down like wild beasts, with blood-hounds, robbed and enslaved; while under pretext to convert them to Christianity, the rack, the scourge, and the fagot were used. Some were burned alive in their thickets and fastnesses for refusing to work the mines as slaves."

Tradition says these acts of base ingratitude were communicated from tribe to tribe throughout the continent, and that a universal wail as one voice went up from all the tribes of the unbroken wilderness: "We must beat back these strangers from our shores before they seize our lands and homes, or slavery and death are ours."

Reader, pause here, close your eyes, shut out from your heart all prejudice against our race, and honestly consider the above records penned by the pale-faced historians centuries ago; and tell us in the name of eternal truth, and by all that is sacred and dear to mankind, was there ever a people without the slightest reason of offense, more treacherously imprisoned and scourged than we have been? And tell us, have crime, despotism, violence, and slavery ever been dealt out in a more wicked manner to crush out life and liberty; or was ever a people more mortally offended than our forefathers were?

Almighty Spirit of humanity, let thy arms of compassion embrace and shield us from the charge of treachery, vindictiveness, and cruelty, and save us from further oppression! And may the great chief of the United States appoint no more broken-down or disappointed politicians as agents to deal with us, but may he select good men that are tried and true, men who fear not to do the right. This is our prayer. What would remain for us if we were not allowed to pray? All else we acknowledge to be in the hands of this great republic.

It is clear that for years after the discovery of this country, we stood before the coming strangers, as a block of marble before the sculptor, ready to be shaped into a statue of grace and beauty; but in their greed for gold, the block was hacked to pieces and destroyed. Childlike we trusted in them with all our hearts; and as the young nestling while yet blind, swallows each morsel given by the parent bird, so we drank in all they said. They showed us the compass that guided them across the trackless deep, and as its needle swung to and fro only resting to the north, we looked upon it as a thing of life from the eternal world. We could not understand the lightning and thunder of their guns, believing they were weapons of the gods; nor could we fathom their wisdom in knowing and telling us the exact time in which the

Fig. 5. A comparison of estimated winter bark (top row) and summer bark (bottom row). Note that although the outer layer (left) of both barks is light in color, the inner layer (right) is significantly darker for the inner layer of the winter bark. *The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University).

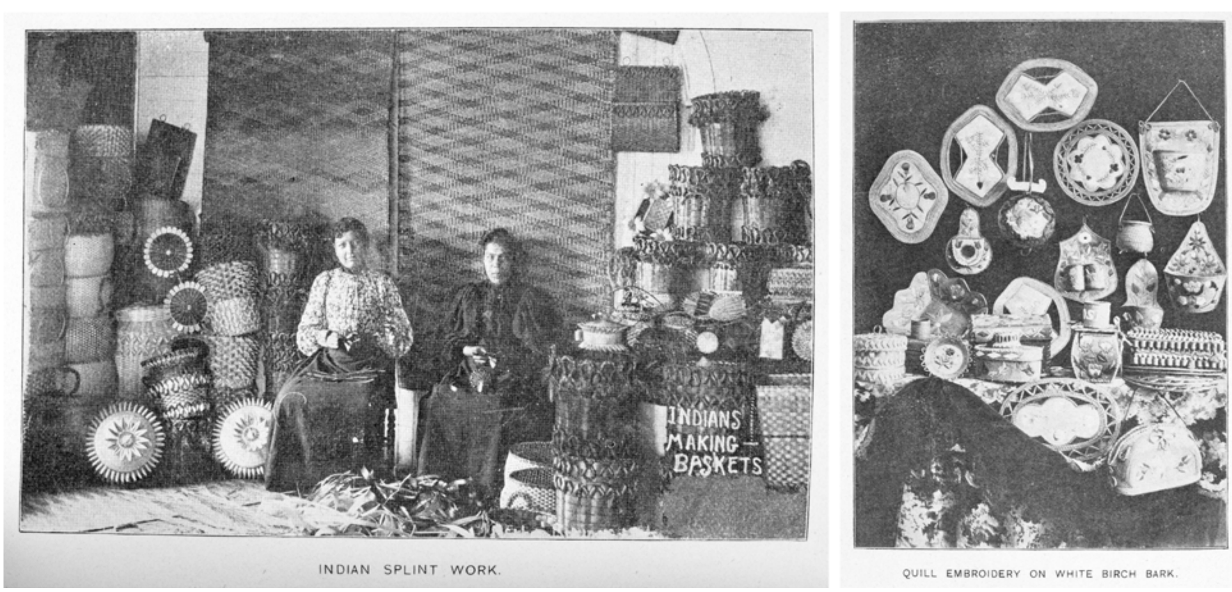


Fig. 6. "Indian Splint Work" and "Quill Embroidery on White Birch Bark" images from *O-gi-maw-kwe Mit-i-gwa-ki, Queen of the Woods*, Simon Pokagon, 1899 (Special Collections Research Center, University of Michigan Library).

Fig. 7. Vertical and horizontal book structures. *Algonquin Legends of Paw Paw Lake*, Simon Pokagon, 1900 (Special Collections Research Center, University of Michigan Library). *The Red Man's Greeting*, Simon Pokagon, 1893 (AC85 P7565 893r, Houghton Library, Harvard University; photo by Laura Larkin).

However, understanding how birch bark was harvested and used by the Pokagon Band may offer clues about when and by whom the birch bark was obtained. While Pokagon's works were printed by a white man, the birch bark may have been provided by Indigenous people who unfortunately remain nameless at this time.

BOOK STRUCTURES

With a better understanding of the materiality of birch bark, its use for book structures was also considered. An online review of historic book structures making use of birch bark revealed that most examples were created in South Asia, such as the Kashmir region. A literature review and conversations with conservators who worked on these types of structures showed that these books are usually sewn with an unsupported link-stitch through sections of folded sheets (Randell 2020; Todd 2017). Dr. Morseau's article on Pokagon's birch bark books also highlights the important connection to birch bark scrolls. Dr. Morseau writes, "While not explicitly mentioned in his texts, Pokagon's use of birch paper to print his works also hints to birch-bark scrolls used by Anishinaabe across the Great Lakes. Those scrolls were and continue to be used to transcribe oral histories, stories, ceremonial knowledge, and other important information through pictographs" (Topash-Caldwell 2018, 52). For sacred or sensitive items, such as some birch bark scrolls, access should be limited to only community members. Many birch bark scrolls are in non-Native institutions under questionable circumstances, including digital images online, so the authors did not examine examples of Anishinaabe scrolls for this research.

Examples of Anishinaabe bookmaking with birch bark were also important to review in order to understand the context of Pokagon's books. One example is from the public-facing Pokagon Band digital archive database, "Wiwkwébthëgen," which includes an image of an undated album-style book with a quilled birch bark cover and blank birch bark pages. The few other examples found in online searches feature quilled birch bark covers, but they do not always have birch bark pages. An important example of this is a book in Amherst College's collection, which has quilled birch bark covers by artist Margaret Blackbird Boyd (Odawa), adhered to a traditional gold-tooled leather-bound binding with a paper textblock containing her brother Andrew Blackbird's text, *History of the Ottawa and Chippewa Indians of Michigan*, 1887. There are examples of non-Native authors and publishers using birch bark for printed books in the 19th century, especially sold as souvenirs in resort towns. One such example in the U-M Clements Library collection, titled "Bay View the Beautiful," was published by Engle's brother in 1892, a year before *The Red Man's Rebuke/Greeting*, and has a very similar book structure as Pokagon's books.

Two types of oversewn codex structures were used for Pokagon's books: a horizontal format with loose pages oversewn along one edge; and a vertical format made of folded sheets that are nested together and oversewn on one edge (fig. 7). In both cases the edges are bound with a green silk ribbon. Often in bookbinding with single sections of folios,

Fig. 8. The combination of vertical lenticels and the birch bark page flexing at the oversewing leads to splits in the page, as seen in the front cover of *The Red Man's Rebuke* (Special Collections Research Center, University of Michigan Library). Photomacrographs (15x magnification) show punched holes and a broken area within a lenticel of *The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University).

the pages are sewn through the center fold with a pamphlet stitch, but this is not the case with the Pokagon books. Oversewing the pages in this manner results in a book that is difficult to open and read, due to the elimination of margins in the center of the book, which has led to many of Pokagon's birch bark books being dis-bound.

CONDITION ISSUES

A major concern with birch bark is that it can split with use due to the naturally weak areas of the lenticels. In handling birch bark samples, the authors found it to be very strong cross-grain, but weak and prone to splitting with the grain, which is in the direction the lenticels run (fig. 8). Much of the damage in these books resulted from the oversewn structure and flexing of the page, with worse damage on pages where the lenticels run vertically. It was also found that the thicker pages of 4–6 layers were stiffer and more prone to splitting than pages of 1–2 layers. The thicker bark were largely idetified as winter bark, with the thinner pages as summer bark. Some books have areas of planar distortion, which pose treatment challenges because the bark is inherently water resistant. Handling and abrasions also led to disrupted bark fibers. The friable nature of the betulin leads to damage or loss of the matte surface. Figure 9 illustrates the loss of betulin in the upper right corner where a catalog number was written in pencil and then erased.

Birch bark has a much lower percentage of cellulose than paper, and the lenticels contain even less, weakening the bark (Maitland 2016, 52). As the bark becomes brittle, it is less able to flex. This, coupled with the natural desiccation of the pectin between the laminates, leads to the natural delamination of the bark (fig. 10). Peeling occurs between the two types of cork cells from different times in the trees seasonal growth. Birch bark is very resistant to deterioration through chemical reactions because it does not readily absorb water due to the waxes and oils found in the bark, and therefore has a low moisture content. It is not prone to acid hydrolysis, which requires water for activation (Suryawanshi 2006, 111).

CONSERVATION TREATMENT

A literature review of birch bark treatments and conversations with other conservators from different specialties provided a better understanding of the material and a foundation for treatment (Adney and Chapelle 1964; Batton 2000; Dignard et al. 2012; Gilroy 2008; Krueger 2008; Kurtz 1997; Maitland 2016; Randell 2020; Suryawanshi 2000 and 2006; Todd 2017). It was also important to consider questions about culturally appropriate treatment of birch bark and examples of conservators working in collaboration with source communities

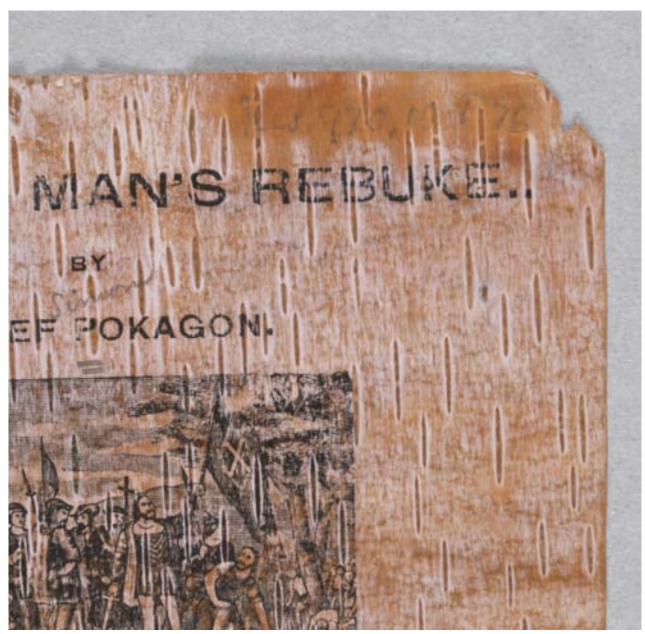


Fig. 9. Loss of betulin due to erasure on the front cover of *The Red Man's Rebuke* (Special Collections Research Center, University of Michigan Library).

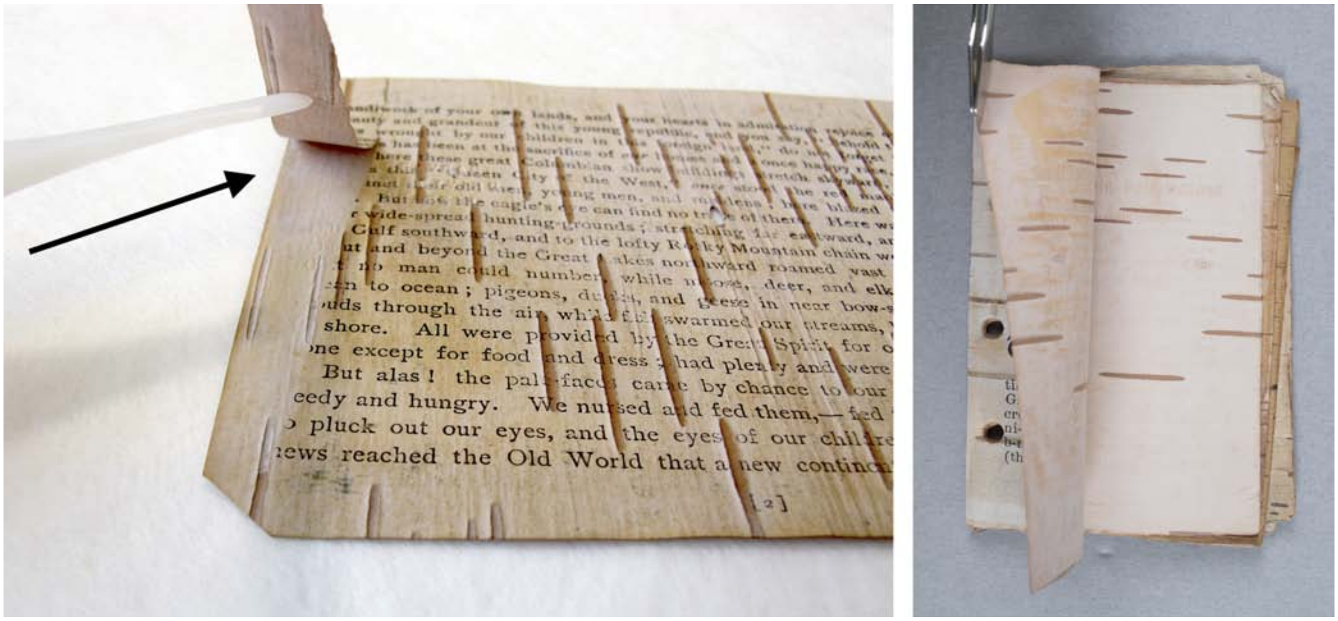


Fig. 10. Delamination of pages; left: *The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University); right: *The Red Man's Rebuke* (Special Collections Research Center, University of Michigan Library).

(Camp 2021; Clavir 2002; Gleeson and Springer 2008; McHugh 2022). Kaye reached out to the Pokagon Band Tribal Historic Preservation Officer and the Director of Language and Culture for the Pokagon Band. However, due to layoffs and the COVID-19 pandemic, communications were brief. Although these books are of incredible historic and cultural significance, they were made for general sale and were written for an audience outside the Pokagon Band. They are not considered sacred objects subject to NAGPRA regulations, and the authors found no specific cultural guidelines for treatment and handling. However, because Pokagon begins the *Rebuke/Greeting* stating that birch bark is sacred to him and his culture, Sjoblom used artist intent and general guidelines on treating Indigenous (also includes First Nations) birch bark items to guide the treatment she performed at the WPC working as a contractor in fall 2020, after completing her graduate internship year in the lab.

The book treated by Sjoblom had splits and delamination throughout but compared to other examples of the Pokagon's birch bark books viewed online, had only moderate damage. In selecting an adhesive for tear and delamination repair Sjoblom wanted one that was biodegradable, like wheat starch paste and methyl cellulose. This is a general guideline for treating organic Indigenous items, acknowledging that these items must have the ability to naturally decompose and go back to the earth (Clavir 2002). Because birch bark is very resistant to water, there was little concern about moisture in an aqueous adhesive causing distortions. However, in testing on samples, water was found to saturate the inner face of the bark, causing some color change (fig. 11). This mostly reversed with drying, but excess moisture was still something to avoid. Organic solvents and alcohols should be avoided because they solubilize components in the bark (Maitland 2016, 56).

Wheat starch paste is more matte, like birch bark, so it was considered for repairs. However, because wheat starch paste contracts when dried, this could cause delamination of the layers. Testing also revealed that repairs with dilute wheat starch paste (Aytex P) were too stiff compared to the birch bark. The book had a library label pasted to the last page,

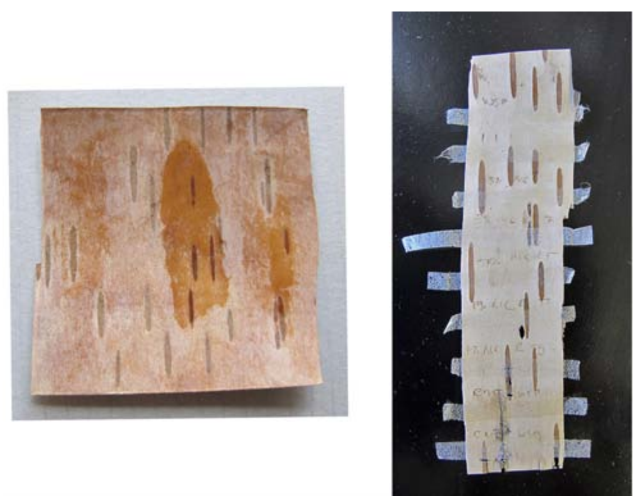


Fig. 11. Darkening of inner face of Sjoblom's birch bark sample due to water saturation (left). Testing adhesives and support materials for delamination and tear repair (right).

Fig. 12. Library label pasted to the last page of *The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University) causing the top layer of the bark to delaminate.

causing the top layer of the page to delaminate—a warning to choose adhesives and support material with great care (fig. 12). Tests proved that dilute methyl cellulose (A4M) provided the most flexible repair, which was required for the thin pages. Methyl cellulose was also considered a sympathetic adhesive to use with birch bark, since they are both composed of cellulose. Remoistenable tissue was chosen to reduce the sheen of dried methyl cellulose compared to brushing methyl cellulose onto the support tissue. Pre-made remoistenable tissue also allowed for the use of a very thin tissue for more subtle repairs. All testing was done on birch bark samples Sjoblom collected in Maine. Unused birch bark samples were not thrown away but were returned to the forest or used for fires. This respect for the material is something Indigenous artists emphasize.

Another challenge was mending a laminar structure. A technique used by conservators at the British Library for bound Kashmiri manuscripts is a woven repair that goes over and under the layers (Randell 2020; Todd 2017). Sjoblom planned to use this technique, but when she started making mock-ups, she found that the birch bark she was practicing on did not have clean breaks, but stepped tears, as did the copy of *The Red Man's Greeting* (fig. 13). These tears were like a scarfed tear in paper and had a beveled edge where the multiple layers of bark did not tear evenly. Therefore, the woven repairs were not suited for this treatment. Instead, repairs were executed from the recto and verso, with one piece of tissue wrapping over the edge to the other side of the page, when possible, to encapsulate the edge and prevent delamination (fig. 14). The difference in the damage, and therefore the treatment approach, for these two types of birch bark books (Kashmiri vs. North American) is important to note. Although both are made from birch bark, the material is prepared differently, with birch bark pages in South Asian books often being made of artificial laminates (Maitland 2016, 52). This highlights the importance of understanding not only the physical characteristics of the material, but also its traditional use and preparation, and that birch bark is used by many cultures globally in unique ways.

Sjoblom used 5.0- and 7.3-gram NAJ Tengucho tissue, pre-coated with 1% or 3% methyl cellulose. The weight of tissue and adhesive concentration were selected based on the color and thickness of the page and the extent of the damage. Because of the color difference on the recto and verso of the pages for the winter bark, the 5.0-gram tissue could be used on the darker side of the page and 7.0-gram on the lighter side, to provide support with minimal visual distraction. For thicker pages with larger tears, the 3% concentration of methyl cellulose was used, whereas 1% methyl cellulose was used for the pages made of 1 to 2 layers. A dry brush and cotton swab were used to tamp the mend into place. Birch bark can easily

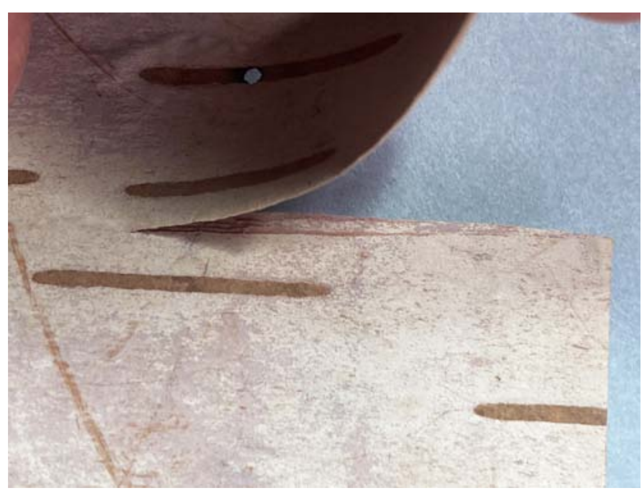


Fig. 13. The "stepped" tears found in Sjoblom's samples, like the tears in the Houghton copy of *The Red Man's Greeting.*

Fig. 14. Photomacrographs (15x magnification) of repairs using 5.0 and 7.3-gram NAJ Tengucho remoistenable tissue (*The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University).

be gouged or burnished, so one must avoid using a bone folder. The pages were not surface cleaned due to concerns that the betulin layer would be disturbed. For delamination, 1% methyl cellulose was brushed onto the surface between the laminates and the page was dried between blotters under a weight. No issues with cockling were observed, and once dry, the flexibility of the repaired areas matched the rest of the sheet. After treatment, the pages were significantly more stable and could be carefully handled by researchers.

REBINDING

The Red Man's Greeting arrived at the WPC lab dis-bound, so the next consideration was to determine what type of binding, or if any binding, was appropriate. Sjoblom proposed rebinding the book to the curator of the collection because of the significance of the combination of a material from Native American written history with the codex structure. Loose pages were also more likely to abrade and catch, especially with researchers handling and restacking them. While it might seem like encapsulation could be an option, in speaking with Kaye about her experience treating papyrus, it became clear that Mylar is not a suitable material to use with plant-based laminar structures because the static can cause delamination. For birch bark, the powdery betulin layer can also easily be disturbed when in direct contact with Mylar (fig. 15).

To allow the page to turn with minimal flexing, the movement of the page had to be at the spine rather than the margin. As illustrated in a model, Sjoblom used the original punched holes to attach the birch bark pages to paper stubs using tackets of Japanese tissue (HM-1 Tengucho/ Tengujo Ash, 11 g/m²) (fig. 16). The paper stubs were medium-weight Japanese paper (HM-57 Yukyu-shi Thick, 41 g/m²), folded into a single section and sewn with a pamphlet stitch. This paper was selected because it has a flexible drape, allowing the pages to lie flat when opened, but strong enough that the weight of the page does not cause the stub to slump or become distorted—similar to considerations for selecting stubbing material for atlas structures. The paper was toned with acrylic paints to match the lightest colored pages. Since the pages varied in color from recto to verso, the stub could not be toned to match a specific page. The pages were attached to the stubs in a manner that ensured that the sewing holes remained aligned by adjusting the

Fig. 15. The negative effects of using Mylar for storage with birch bark: delamination (left) and transfer of friable betulin layer (right).

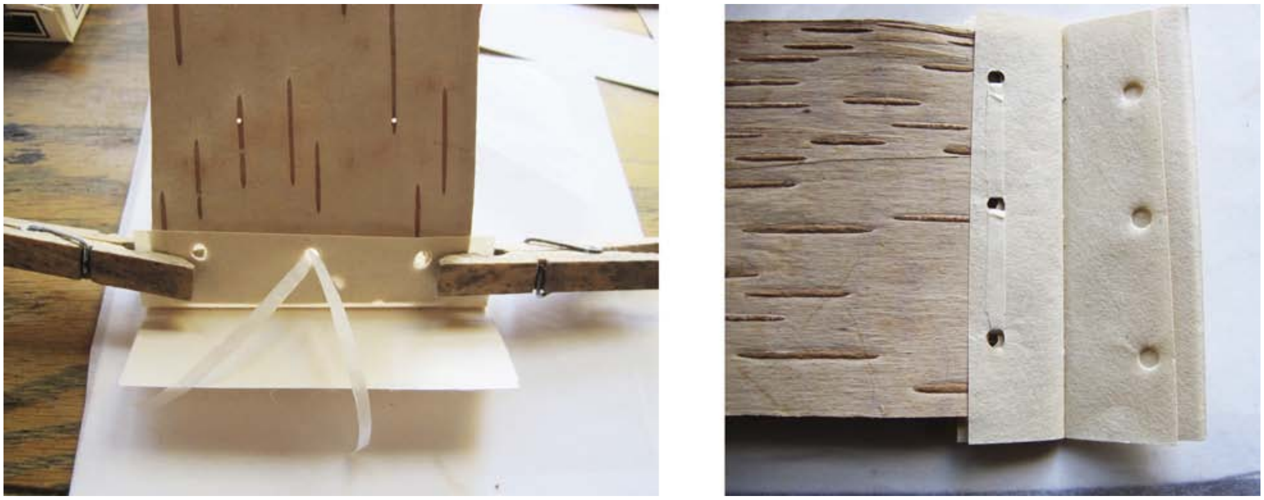


Fig. 16. Sjoblom's book model, indicating the paper stubs and tackets.

placement of the holes in the stub, starting with the pages in the center of the book, and moving outwards towards the front and back. A Japanese hole punch tool was used to punch holes in the stubs, and then thin strips of lightweight tissue were passed through the holes in the stub and page to secure them together as tackets. These binding tacket strips were secured to themselves with wheat starch paste forming a loop. The weight of the tissue for the tackets was selected to be strong enough to support the page but thin enough that it was transparent and not distracting and did not abrade or stress the birch bark at the punched holes. To keep the page from flexing and moving away from the stub when the page is turned, small tabs of the remoistenable tissue that had been used for the repairs were also adhered along the spine edge of the page, securing it to the stub. Sjoblom also relaced the green ribbon through the holes only on the title page. This gives users a suggestion of the original structure and indicates that the current structure is not original, but does not limit the opening of the book. The book can now open fully for easy access. This new structure is reversible, which is an important element when changing a bookbinding structure, allowing for new ideas and future considerations (fig. 17).

LONG-TERM PRESERVATION

There are many preservation options and considerations for Pokagon's birch bark books. Given the goals of the institution, intended use, and condition of the birch bark, rebinding was a good option for the treatment at WPC. However, given that many of these books in library collections have been digitized and images are readily available, some custodians of the books may choose to leave the books bound with the original ribbon. This results in limited handling because of the risk of damage opening the oversewn structure. Current interest in these books means they are being used more often, and it is likely many will be dis-bound, making examples of the original structure more difficult to find. Because of the simplicity

Fig. 17. After treatment images of *The Red Man's Greeting* (AC85 P7565 893r, Houghton Library, Harvard University). These images show the new stubbed bookbinding structure and ease of opening.

of the original structure, images and written documentation may be adequate records. The benefit of handling the pages and ability to carefully examine the books to find differences in editions and birch bark qualities must be weighed against the risk of damage in handling, or changes to the original structure. Some collections have made facsimiles of the books for researchers to handle instead, such as the Bentley Historical Library at U-M.[2] Depending on the quality, facsimiles can recreate many aspects of the books; however, the tactile experience of handling birch bark and the variations of page thicknesses cannot be conveyed.

Housing is also very important for these books. For the housing of Harvard's *Greeting*, Sjoblom used smooth stiff materials that would prevent the book from being flexed and not cause abrasion. She made a four-flap cardstock enclosure and modified a pre-made folder to safely hold the book. This folder is large enough to prevent the book from being lost on the shelf. An example at the Bentley Historical Library at U-M is housed in a large clamshell box for this reason. Any rough surfaces should be avoided, including uncovered foam and padded wedges often found in reading rooms.

Proper environmental conditions will also prevent damage to birch bark. Environmental factors to consider include temperature, relative humidity (RH), light, pollution, and pests. Birch bark is very resistant to water compared to paper. Whereas paper will often absorb water in a few seconds, birch bark requires 24 hours for at least partial absorption (Suryawanshi 2006, 105). However, early and late cells in the bark respond differently to changes in RH, which can lead to curling of the bark (Maitland 2016, 52). Because the desiccation of the natural pectin adhesive between the layers leads to delamination, a low RH is not recommended. Kicknosway also takes this into account, as he is at a high elevation in Montana and notices the difference in how dry the bark gets compared to when he works with birch bark on the East Coast. The cracking and curling of birch bark happens faster and easier when the RH is very low. Birch bark can therefore be safely stored at about 55% RH. Anything higher introduces the risk of mold growth for typical library collection materials such as paper, leather, and parchment (Wilson 1995, 1). This is not as much of a concern for birch bark because of its resistance to biodeterioration, but since birch bark books are often stored with other paper-based collections, this is a suitable RH. When it comes to an ideal temperature for the storage of organic materials, 65–70 degrees Fahrenheit is the accepted standard (Wilson 1995, p. 2).

Light can cause color change to birch bark and should be limited by storing the books in protective enclosures. This is also a consideration for exhibition. Even without light exposure, color change can occur in dark temperature- and humidity-controlled environments with elevated and fluctuating conditions, especially in the red to orange-red colored winter barks (Tse et al. 2018, 439). Fortunately, birch bark is very resistant to fungal and insect damage, largely due to the betulin content. If the storage areas are kept clean and the environmental controls remain steady, concerns about pests can be kept to a minimum.

CONCLUSION

While conversations with other conservators helped to establish treatment protocol for these books, speaking with experts outside of conservation was vital to understanding the material and context of the books. Although it is common practice for conservators to reach out to colleagues in other labs, it can be more challenging to make connections outside of conservation due to lack of familiarity with resources and organizations. However, there have been generations of work and collaboration around caring for Indigenous collections from which conservators can learn. Conservators who build a foundation in this collaborative way of working can ask more informed and respectful questions when reaching out to experts in other fields and representatives from source communities.

As conservators become more familiar with the legal requirements of NAGPRA and ethical considerations involved in conserving Indigenous collections, this project highlights ways to go beyond basic requirements. Although no restrictions were found for the treatment of these books due to their intended sale outside the Pokagon Band of Potawatomi, understanding the context of the books and the sacred use of birch bark was pivotal. The conversations with Anishinaabe artists and scholars were eye opening and amplified how much the authors would have missed without these voices. Further conversations and more time would have certainly yielded even more information and understanding, particularly to have spoken more with official representatives of the Pokagon Band of Potawatomi. As conservators who had not previously treated Indigenous items, through this process the authors learned many lessons about guidelines, collaboration, and timelines, which they will carry into their future work.

The authors found it beneficial to share what they learned through their examination of the books whenever possible and appropriate, and this helped create more reciprocal relationships and led to their contribution to *As Sacred to Us*. Compensation was not provided to the artists interviewed for the chapter in *As Sacred to Us* due to it being independent scholarly research for a publication connected to the Pokagon Band of Potawatomi. However, the SAR guidelines recommend that community members be compensated for their time and expertise (Indian Arts Research Center 2019, 5). As a field we should acknowledge the benefit of conservation departments developing general consultation guidelines ahead of time, including if and how compensation can be given.

The use of birch bark in Pokagon's books has been described partially as a marketing technique to attract buyers in the Victorian tourist trade. However, through research and artist interviews, the authors understand the use of birch bark as a strong political and environmental statement by Pokagon, which also carries with it a unique charm that draws people in to learn from his writings. The Indigenous knowledge and tradition involved in the use of birch bark should be in the forefront for all who handle the books. When studying Pokagon's books, we must consider who made them, past and present access to birch trees and land, and intergenerational knowledge. Although many questions remain about how these books were made, gaining a deeper understanding of birch bark as a material and its use in Anishinaabe culture helped guide the thoughtful conservation treatment of these books. This now allows researchers to study them firsthand and to continue seeking greater knowledge and understanding of a material and its role in Anishinaabe futures.[3]

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NOTES

1. Refer to https://native-land.ca to look at the land of the Anishinaabe.
2. The Newberry Library online catalog lists a facsimile in the record of their copy of *The Red Man's Greeting*, but neither author viewed it in person or online.
3. The authors shared the following resource list during their presentation: https://tinyurl.com/2kmw4n97

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SOURCES OF MATERIALS

NAJ Tengucho tissue, 5.0 and 7.3 g/m weights, made by Hidaka Washi in Kochi, Japan, purchased from Hiromi Paper, Inc., used for repairs.

Methyl Cellulose A4M (viscosity 4000), purchased from Hollinger Metal Edge, Inc.

Wheat Starch Aytex-P, purchased from TALAS.

HM-1 Tengucho/Tengujo Ash, 11g/m² weight, purchased from Hiromi Paper, Inc., used for the rebinding tackets.

HM-57 Yukyu-shi Thick, 41 g/m² weight, purchased from Hiromi Paper, Inc., used for the stubs.

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Sewing, Adhesion, and Grain Direction in Book Conservation

INTRODUCTION: BOOK STRUCTURES

Book conservators do not look at bindings primarily by their age, provenance, or style, but by the extent of their damages in relation to usability (handling, digitizing, or exhibiting). It is therefore fundamental to classify the features of the book according to their durability for use.

The structure of a book is the way each component is connected to the whole—its skeleton—and affects how the binding functions. It determines the **motion** of the parts during regular use. Book terminology does not clearly communicate these relationships. Nonetheless, conservation requires a deep understanding of structural weaknesses and strengths towards the goal of extending book longevity

The essence of book*binding* is the *binding*, understood as a link between parts. There are two main types of connections for the parts of a book and their contribution to the structure: how folios in a text block are attached together, and how the covers are attached to the text block. As for how folios are attached together in a text block, there are also two main types of connections, for they can only be **sewn** or **adhered**.[1] The materials and techniques used for these areas define how the book moves when handled and can advise against certain handling methods. For instance, tight-back bindings should not be pried open, as the strain on the spine can cause it to break.

Each component plays its role and should not be dismissed (e.g., fastenings, endbands, pastedowns, flaps, and corners) but considered according to their contribution to the structure (and the condition of the book). All in all very few elements are merely decorative: a glimpse on the archaeology of bookbinding shows the extent to which most components are devised to play a specific function. Evolution and improvement of some parts have only pushed others into the background, often involving alternative setbacks. In Szirmai's (1991) words, *"the history of craft bookbinding technique shows that improvements have seldom been achieved without concomitant drawbacks."*

Papers presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

BOOK STRUCTURES AND CONSERVATION

Conservation should not intend to improve or correct an artifact, but only its condition. Although bindings are innately suitable for their context, conservation often aims to preserve them beyond their intended lifespan. As such, merely preserving each of the materials is commonly not enough for books, as a minimal manipulation is required to access their contents. Weak structures that do not allow for safe handling or involve hazards need to be fixed.

A study of structural weak points and strengths is valuable to set preservation policies and paramount when it comes to conservation. The original structure needs to be understood, the condition of the materials and their damages considered, and finally a conservation treatment that fulfils the book's present needs should be set, with regard to function and available resources.

STRUCTURAL PARAMETERS FOR BOOK DESCRIPTION

Conroy (1987) developed a comprehensive study of the most significant structural elements, which he grouped in linings, sewing supports, and joints. Lining refers to materials applied to the spine, building up layers that affect *tension* and *compression*.

These two terms provide very useful distinctions for structural purposes because they refer to movement and straining (damage) and enable a clear differentiation of the diverse layers gathered in a spine, which are not always that distinguishable—specifically those operating conjointly on a tight back.

The way linings, joints, and sewing supports are connected does explain the motion of a book, but not all books have sewing supports nor any sewing at all (e.g., board books and many albums), and neither are all spines lined. In early medieval long stitch bindings, for instance, the spine consists solely of an unsupported sewing, devoid of any other layers.[2]

A structural classification according to types of links (namely sewn or adhered) can be applied to any kind of book, not precluding those that lack spine linings or sewing supports. A general description should not miss describing the main bonds (folio-to-folio and text block-to-covers) as their characteristics and interaction describe the movement of the book. Describing specifically any other damaged part on this basis is certainly most advisable. Ultimately, motion is the most common cause of damage. This can be derived from handling, but other factors involve the swelling and shrinking of connected materials overtime. Age and environment, for instance, also contribute to movement in the book, microscopic and silent, but which can result in the detachment or failure of attachment points.

On the other hand, the same structure can behave diversely according to the nature of each material. As Conroy (1987) points out, "tight-back bindings vary greatly in action according to how much the leather has been pared." The pliability, thickness, condition, and other features of the bound materials need to be considered accordingly.

SEWING AND PASTING: FEATURING ENDURANCE TO USE

Sewing and adhesion—the primary types of unions between book components[3]—have unique effects on the behavior of book pliability. It is well known that adhesion stiffens and compacts whereas sewing confers flexibility.

Finding the right balance between sewing and adhering is the key to achieving an enduring and easily handled book, no matter how antagonistic these two concepts might often be. As noted by Clarkson (1975): "Since the 1500's […] bookbinders have thought less of the basic sewing structure and placed reliance more on adhesives […]; having no understanding of the subtlety and nuance of sewing structures."

Considering the ways in which books are found to be damaged, it can be ascertained that, in moveable book components, sewn attachments tend to endure better than adhered ones. Despite what one may assume, sewing—which requires creating a hole—weakens less than adhesion because it allows motion with no threat to flexibility, even when the conjoined parts behave diversely. Handling and relative humidity compel each material to swell or shrink as they would do on their own, with the only effect on the sewn system to become more or less taut. If tension is not enough to cause breakage, none of them is endangered. The strain is reverted when conditions revert to their initial state with eventual loosening due to repeated use or decay.

Conversely, the addition of glue stiffens materials. Glued materials are more prone to cracking when bent. Porous materials become more compact and less hygroscopic when glued. Strains arise when adhesive is applied only locally because of the dual behavior at the edge: the backed area stretches while the neighboring zone curls. Thus, adjoining areas are subject to rip along the gap of different docility. Likewise, the edge suffers a major stress under relative humidity variations.

As opposed to sewn unions, the system does not go back to its initial state after releasing strain: either they endure or simply fail (detach, break, rip).

Adhesion strengthens when it comes to static areas (generally within the boards: corners, pastedowns, covers, etc.) but weakens areas that require movement (mainly folios, joints, and spine [fig. 1]; but also fastenings, guards [fig. 5], endbands, etc.).

The fundamental concept has since always been applied and underlies referral recommendations, such as Szirmai's: "[The 'quarter-joint' structure's] virtue lies in the adhesive-free zone along the joint, which has been recognized as an advantage"; or Clarkson's (1975): "In conservation work one needs to use minimum or no adhesive in the spine and certainly not for any structural reasons," to quote just two.

Endbands are a very simple example: sewn endbands are often found broken—but still extant—as opposed to the frequency with which pasted endbands are lost due to full detachment.

OTHER STRUCTURAL FEATURES (GRAIN DIRECTION AND DISPLAY)

Provided that bonds of the same type have a general similar behavior, two bonds of the same type can vary greatly depending on their intrinsic features. For instance, an adhered union between text block and covers shall behave quite differently if the endleaves are of parchment, rather than paper. Some materials enhance a structural grounding whereas others restrict it. For example, wooden boards are lighter but much harder than paper-based boards, being a superior protection against mechanical hazards (abrasion, hits, etc.). Given that the conservator's choices fulfill historical and aesthetical appropriateness, it is worth noting that the same material embodies a stronger structural basis when strategically applied as well as prevents setbacks in the long run. As a case in point, text-block sheets are laid out with the grain parallel to the spine in order to ensure sufficient drape, devoid of strains by the sewing. It is by no mere chance that medieval wooden boards were also oriented with vertical grain direction, often reinforced with cross-grained butt joints to prevent cockling (Honey and Velios 2009).

Under the same principle, different areas of a part have specific demands. A pliable spine calls for more flexibility at the joints than in the center. A pared or thinned-down reinforcement shall be more flexible than a straight one because instead of a single sharp edge delimiting two areas of diverse flexibility, there shall be several neighboring zones of decreasing pliability. The difference for adjacent regions is therefore

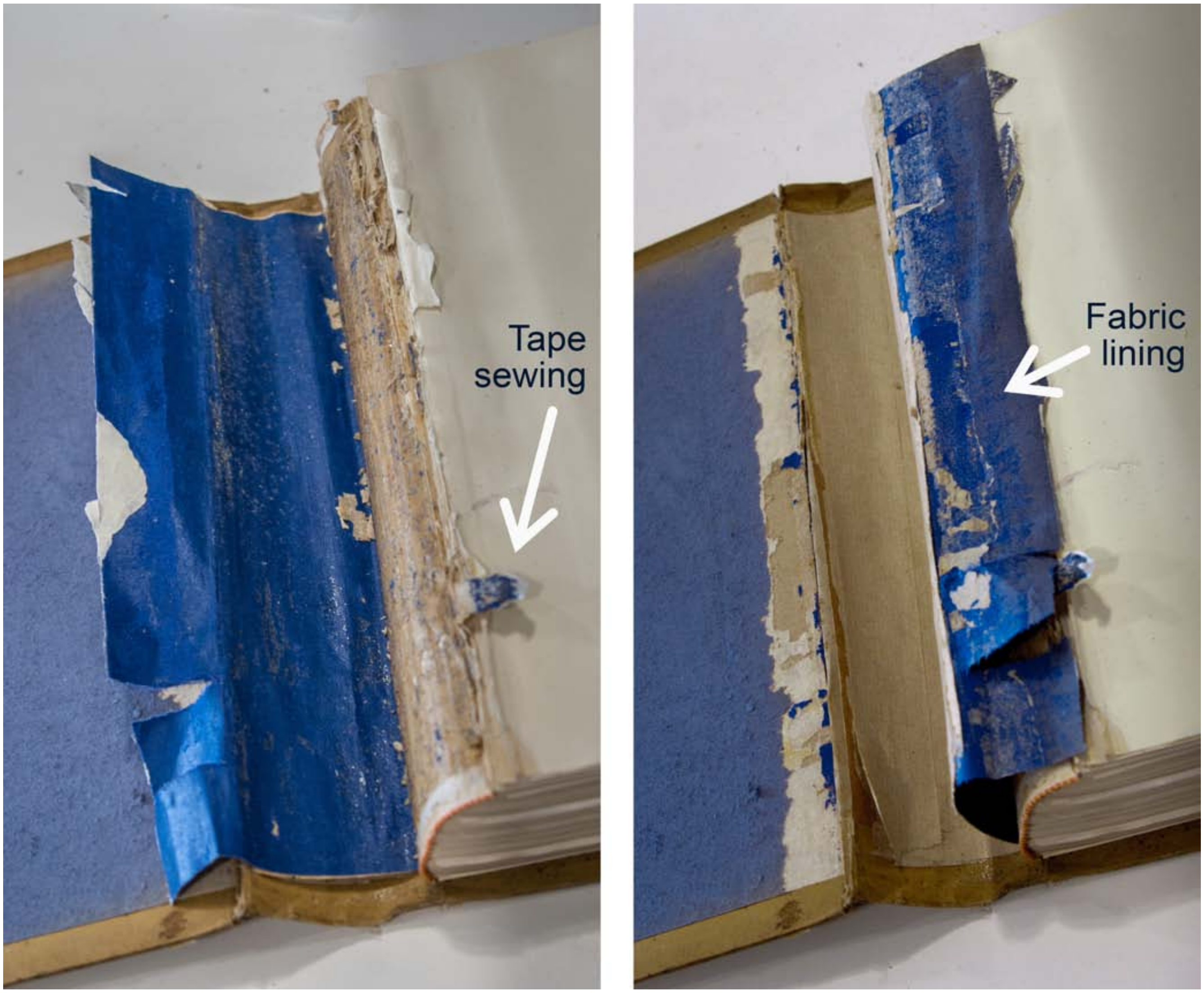

Fig. 1. Book sewn on tapes with adhered fabric spine lining. The original reinforcement devised by the bookbinder has not been enough to hold the heavy text block. The backed part on the movable area (spine) was detached, whereas the static stubs under the pastedowns remained adhered in place. The fabric stubs appear unstuck in the image just after being detached by the conservator in order to replace it with a mull. *El Mercurio* (c. 1930), from the Historical Archive of Barcelona.

much bigger in the first case. In other words, some distributed minor weak points present less threat than a single major one.

Elementary concepts arise when extrapolating this principle to primary attachments with much applicability in conservation. For the board-attachment connection, a union consisting of several hookings along the joint is more stable than one with a reduced number and performs better when evenly distributed. The same basic principle applies when hanging out the laundry by just one clothes peg (or two or more): the more pegs, the less strain and distortion. Pegs and working time are saved if clothes are simply folded at the middle, applying a similar even force all along the fold, but the lack of hooking has obvious risks (see figs. 5 and 7).

The practical effect of this tenet consists in securing the joining all-along (see figs. 4 and 6), rather than only locally (e.g., a damaged thong). Therefore bracing materials can be lighter, and strains are minimized on the attached parts while being very durable. If none of the bonds are sewn, bear in mind the gamble of using no clothes pegs!

Resuming the benefits of sewing vs. adhesion, a comparable superiority of fabric tissues over paper is to be expected. Concerning mechanical behavior, fabric is more flexible and tenacious than paper. A close up explains it: a tissue consists of woven *twisted* groups of threads (Steere 2022), whereas paper is composed of entangled (and sized, that is *adhered*) single fibers. In turn, papers offer a wide range of structural natures: rag paper lacks grain direction, therefore tears are not

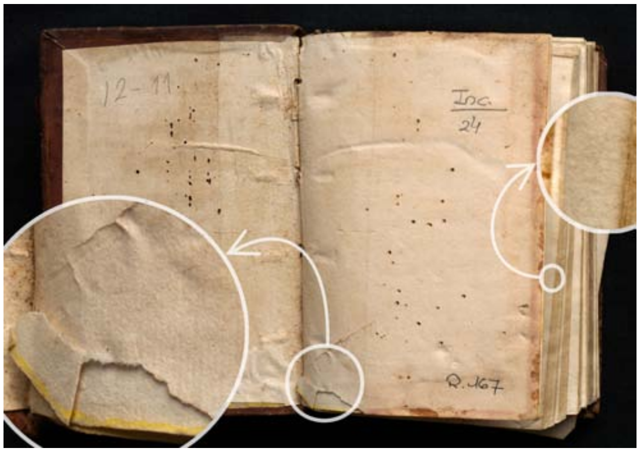

Fig. 2. Incunabula dated 1499 from the Public Library of Girona Carles Rahola (R. 167). The endpapers have horizontal grain direction (lower detail) whereas the text block folios have lengthwise grain (detail at right). The endpapers are less apt to tear apart along the joint since ripping is encouraged horizontally (bottom detail).

favored on a particular orientation. But machine-made and laid paper do tear easier along the grain. Moreover, the fiber length and compactness of paper also defines its performance (swelling, pliability, resistance to tear, and so on).

A personal observation of the author states that endpapers before the 17th century are sometimes found cross-grained while the text block has the *right* vertical grain (fig. 2). It is strongly encouraged to quantify and define the context in which this happens. Still lacking proper research, these findings seem too frequent to be the cumulative result of a slovenly crafting performance. It simply provides reasonable grounds for belief of an intended action. The goal would be to lessen the risk of tears along the spine-fold derived from half the adhesion of endleaves (solely the pastedown). Strength on joints might have been prioritized to an easier and well-groomed completion. It appears unsound that experienced craftsmen did not foresee the singular swelling of half laid paper against the grain. The struggle with the wavy joint and a pastedown taller than the flyleaf might have been the compromise to prevent full detachment of flyleaves. Earlier and contemporary structures deliberately reinforced this weak point (Blaser 1994)—either using vellum stubs instead, or in multiple options of hooked stations. Therefore, endpapers depict not only a covering material, but a material integrating significant attachment points (thus, structure).

Be that as it may, it can't be neglected that grain direction makes paper very vulnerable to tearing when the ripping angle starts along the grain, but is most resistant to tearing perpendicular to the grain. Let's take advantage of this fact as a way to bestow structure to those elements that might require it, just like experienced bookbinders have been always doing.

DISPROPORTIONED BOOKS

Proportionality of bindings does not refer to unusual dimensions, but rather to the capacity of a structure to endure, protect their contents, and be handled. Disproportion means that some vulnerability shall make the book collapse even when their components are in good condition. For instance, a book can be disproportionate if the cover–to–text-block attachment is too weak to sustain it (or if the text block is too heavy, as shown in fig. 1), the edges much too high (as in fig. 3), or the spine much too stiff (as in fig. 8). Typically

Fig. 3. Disproportioned book from 1871 before (a) and after conservation (b). Left: Images taken from above the head of the book. After conservation (b) the book is able to stand without the text block falling apart from the spine whereas before (a) a weight was needed to hold the book upright (black piece on top). Association of Architects of Catalonia (CoAC).

Fig. 4. Sewn reinforcement over a mull. The sewing hooks the gatherings distributed all along the spine, not too close to each other. Note that the original spine lining has not been removed, only the loose areas.

disproportioned bindings are, for instance, heavy cased-in books whose endpapers are the only cover–to–text-block attachment point.

Most concerning structural damages involve detachment of the folios and/or covers. However, many other parts should be taken care of according to their relevance and function in a book: ties, clasps, endbands, spine, flap, and so on.

Depending on their proportions, bindings with the same type of structure can behave very differently in terms of durability. All features (size, weight, type of material) matter. When books have failed due to a disproportionate binding structure, merely fixing the damaged parts may be enough for exhibition purposes but may not be enough for more intensive use.

EXPERIMENTATION

In daily conservation, the above concepts can be applied in practical terms, as demonstrated in the following case studies. All of them consist of disproportioned bindings with major structural damages (board and folio detachment). They are not meant to be followed as step-by-step treatment formulas, not even in reference to precise products or materials, precisely because conservation treatments need to be tailored to the context and nature of each artifact. These case studies are not the result of a planned research project but selected from routine treatments in the conservation lab. There is still much room for research and improvement of analytical design.

Through these case studies, this article intends to highlight this underlying idea: the strength of the skeleton of a book is based on types of bonds and the structural complexion of their components. Each conservator should use familiar materials and techniques to achieve a more stable and endurable structure.

CASE STUDY #1: HEAVY BOOKS

Text blocks that are too heavy can weaken certain types of board attachments. A combination of factors that can lead to failure include excessively thick text blocks or those made of heavy paper (e.g. coated papers); sewing cords that are recessed, too narrow, or too frayed; and boards with excessive squares. If the original combination of components produces a weak binding structure, conservation will not succeed by merely repairing all the broken parts and reproducing the same structure. With a recessed sewing structure that was too weak to support its text block, case study 1 featured many of the components mentioned above to form a failing structure. The selected treatment demonstrates the superiority of sewn reinforcements over adhesive ones for areas of movement (fig. 3).

For the joint, the area of the book requiring the most motion, the chosen reinforcement material ought to be highly flexible and endowed with structural integrity. For example, woven fabric is preferable to non-woven (e.g. synthetic spunbond) materials, which have less grain direction. Similarly, non-woven materials are preferable to paper, which has a weaker bond between its fibers despite its good grain direction. A reinforcement material that is optimal for the repair of a part of a book can be detrimental to another part depending on its contribution to the structure of the binding. The type and length of composing fibers, thickness, compactness, and many other features of the material thus need to be considered accordingly.

Hollow-back spines are reasonably accessible to the conservator, specifically for books with detached boards. Furthermore, they tolerate the addition of a moderately thick layer over the spine while not protruding nor being visible after conservation. Thus, a mull is preferable for this particular case. Considering that the attachment requiring strengthening is that of the boards to the text block, the mull is oriented with more tenacious warp yarn across the spine (Steere 2022), strengthening the connection between boards and folios.

Next, the mesh is held on the text block. It is not recommended to remove or replace older spine linings whenever they are firmly stuck, for this might loosen the gatherings, distort the spine, and eventually involve breakage of some folios. The union of the mull onto the spine is unquestionably sewing (see fig. 1). It is more time consuming than pasting but will last longer. A random sewing collecting both the mull and the gatherings will suffice (fig. 4). The mull is intended to replace the role of the weakened thongs by relocating strains along the spine, thus the sewing is preferably held directly through the gatherings rather than just the thongs. The new sewing shall be well distributed in order to divide up the stress and the stitches not too close to each other so that the mull is not weakened by an excess of holes.

The mull can be previously held onto the spine with a light layer of methyl cellulose to facilitate sewing. This optional step is negligible in relation to reinforcement purposes but meant uniquely to ease the conservator's performance.

Ensuing the text block sewing, the stubs of the mull are to be held onto the covers. Unfortunately, a sewn hooking is ordinarily not a sensible option since it would require detaching along the joint both the endpapers and the binding's covering material. For most common materials (e.g. decorated papers, printed cloth), a haphazard outcome is to be expected. The board material usually employed for covers is then slotted along the joints' edge and the mull stubs inserted in a few centimeters.

The structure is then reinforced: joints and spine—the movable areas—are endowed with materials embodying the skeleton and rely mainly on sewn bonding. A heavy book can then stand on its own, proving it has a solid binding.

CASE STUDY #2: ALBUMS, BOOKS WITHOUT SEWING

In photographic albums, the contents are inserted after the book is bound, which needs to be flexible to endure handling and accommodate the photographs. Yet in many cases, such as the one shown in figure 5, the folios are simply adhered to each other through guarded fabric stubs. Adhesion does not ensure a pliable structure, therefore sooner or later the tipped-on pieces might tear apart or detach from each other, regardless of the type of material. The covers may also become disjoined due to the severe damage.

Treatment is similar to the previous example. The tears of the guards are mended in advance, in this case with Japanese paper thinner than the guards and cross-grained in relation to the spine-fold (regardless of the grain of the guards). In such a way resistance to tearing is minimized and the link exerted by the sewing is stronger. For a neater finishing, the innermost side of the gatherings (that visible from the spine-fold) is mended with a much thinner Japanese tissue whose grain is lengthwise to the fold. The contribution to structure of the visible mends is trivial, just preventing them from opening and ensuring a tidy and uncluttered fold. Since there was no sewing before conservation, the sewn reinforcement—again over a mull—needs to hook every gathering, preferably from head to tail (see fig. 6). The boards are reunited as in the previous example, inserting the mull stubs into the slotted boards.

As a result, the restored book is far more enduring (see fig. 7). The sewing restricts excessive stress towards the guards and prevents them from splitting apart. Thus, it is possible to repair the spine-folds with light, pliable, and not very visible mends (previously dyed for a better match).

Fig. 6. Album from the Photographic Archive of Barcelona, after sewing the gatherings over a mull. The stubs of the mull are inserted inside the boards of the covers (on top), which have been split for this purpose. Black thread is used to match the color of the guards.

Fig. 5. Album from the Photographic Archive of Barcelona, before conservation. The guards were detached and torn apart. Folios had been compiled devoid of any sewing but stuck together with folded guards. Albums require a flexible skeleton that adhesion cannot provide, despite employing an appropriate material such as fabric.

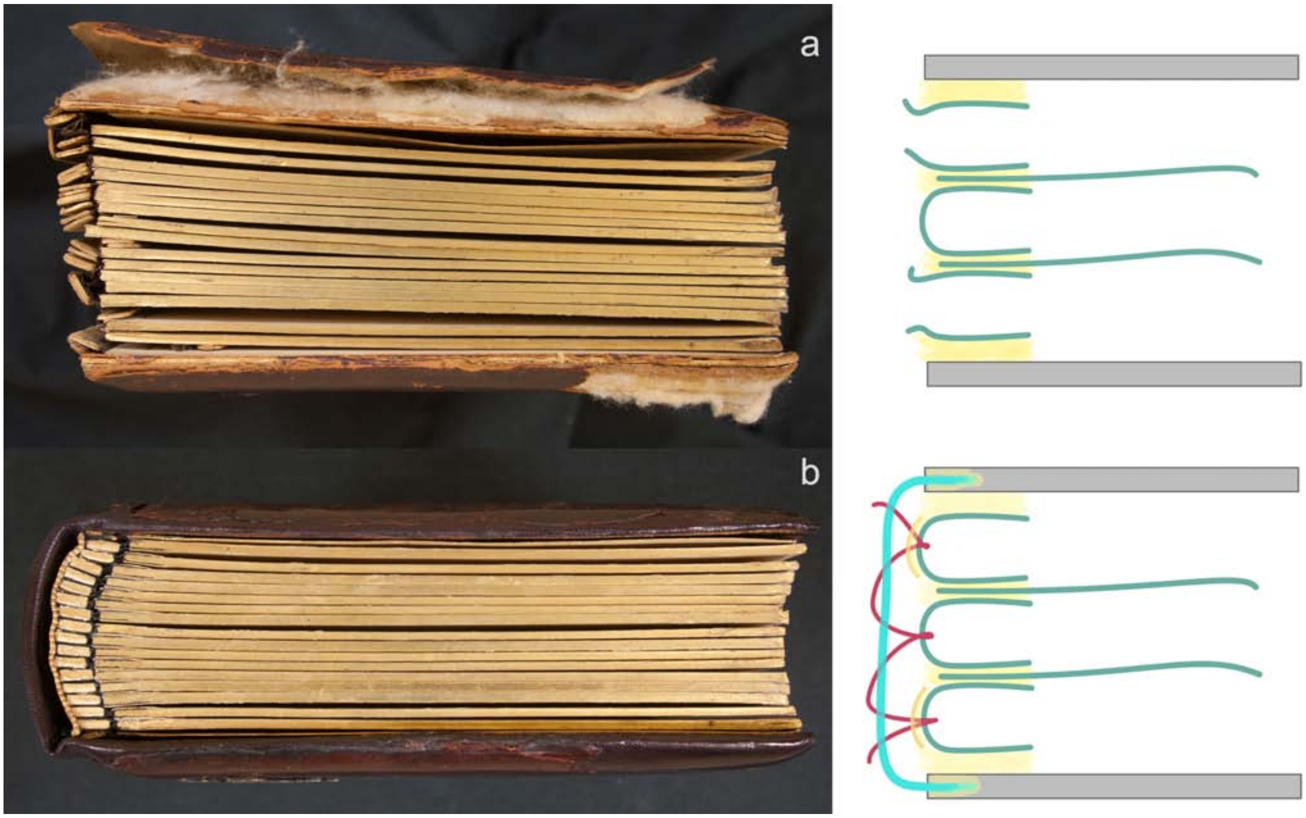

Fig. 7. Album from the Photographic Archive of Barcelona, before (a) and after conservation (b). Light adhered mends were applied on the guards, and an invisible sewn reinforcement (using black thread) supports the structure. Left: head edge before and after. Right: structure before and after. The mull, in blue, adhesive in yellow, thread in red, boards in gray, guards and folios in green.

CASE STUDY #3: SEWN UNSUPPORTED BOUND BOOKS

Sewn, unsupported books lack proper covers, the binding consisting merely of a printed paper adhered onto the spine. The link between the folios is often quite unsubstantial since they were commonly meant to be re-sewn and fittingly bound after acquisition. The sewing indeed lacks sewing supports and is often more localized in the center, leaving the head and tail unconstrained. The reason is a potential trimming of the uncut edges and also the temporary quality of a sewing intended to be rebound.

In a similar manner to the previous case study, both main structural connections are frail, but additionally the printed spine-support is often massively cracked (see fig. 8). Nonetheless, the tight-back spine does not tolerate many added layers, nor can the paper covers can be treated as a thick cardboard.

At worst, a possible solution is to turn the spine into a hollow-back, releasing stress in the printed spine (see fig. 9a) and strengthening the sewing. The wrapper is first detached from the spine and mended. Alternatively to the stronger reinforcements used in the previous case studies, a much lighter piece

Fig. 8. Sewn, unsupported book bound in drawn-on covers from ETSEIB, UPC (Superior Technical Engineering School of Barcelona, Polytechnic University of Catalonia). Massive cracking along the spine material, board detachment, and friability of the unsupported sewing.

of Japanese heat-set tissue is used. This is adhered onto a synthetic mesh (e.g., a Reemay, rather than thicker fabric layers; see fig. 9b). The paper tissue is displayed in contact with the spine with its grain direction across the joints and with the

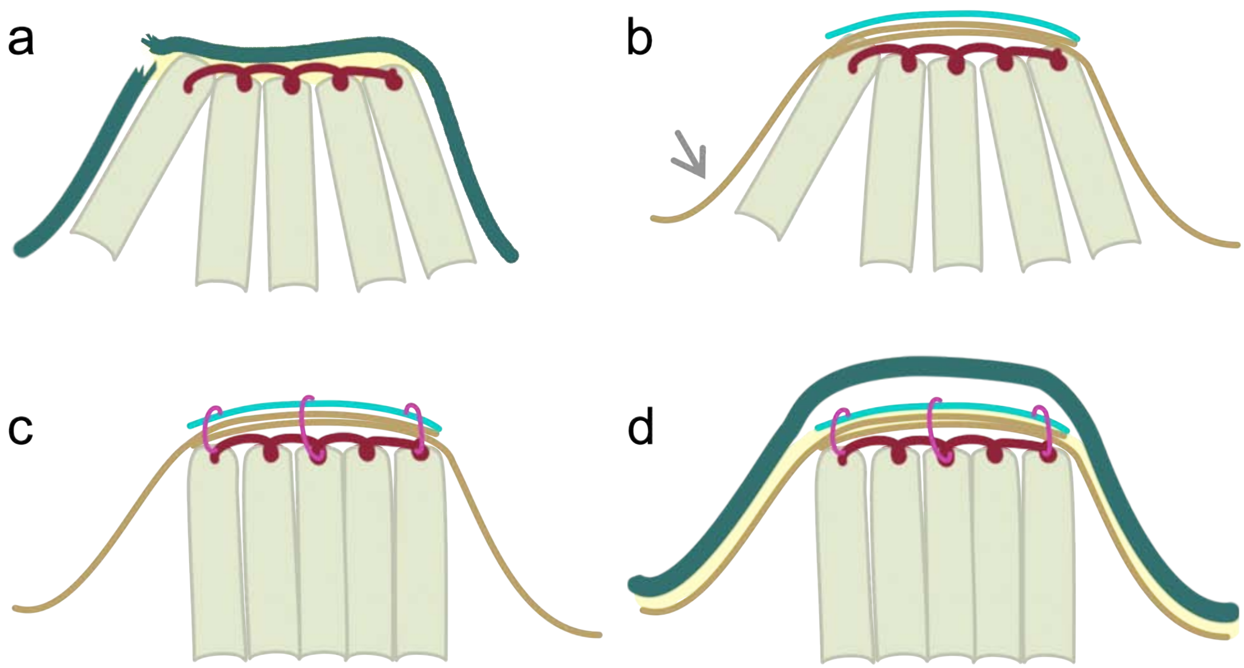

Fig. 9. Structure of same book as previous figure. a) Before treatment, the sewing is frail (in red) and the covers (green) are detached along the joints. Adhesion (pale yellow) applied on the tight-back. b) After removal of drawn-on covers two layers of hot-melt tissue (brown) are placed onto the spine, with the adhesive layer–pointed by the arrow–facing up. On top, a layer of synthetic mesh (blue), a Reemay. c) A secondary sewing (pink) gathers the text block and the Reemay, restricting minimally the motion between gatherings. d) The restored covers (green) are adhered (yellow) onto the hot-melt tissue (brown) remoistened it with ethanol. The spine of the drawn-on covers lack strains because it is adhesive free and does not compress. The text block is sewn. The covers and text block are linked along the joints by means of the cross-grained Japanese tissue, which is sewn both on the text block and the Reemay.

adhesive layer (indicated by the arrow in fig. 9b), facing the synthetic mesh. The paper is meant to be adhered lengthwise to the joints of the wrapper. It can be as large as the covers, thus preventing potential tears along the edge of the heat-set tissue and endowing a proper drape. If the covers are printed on both sides and readability is compromised by the tissue, a few centimeters along the joint will suffice. Afterwards, the text block is re-sewn over the paired materials (see fig. 9c). Again, it is suggested that it goes all along the spine, rather than being gathered at the center. Subsequently, the adhesive of the heat-set tissue is activated by spraying ethanol and immediately stuck to the inner side of the restored wrapper (fig. 9d). The use of ethanol (or heat) instead of water-based adhesives avoids fiber swelling and distortion of the printed wrapper.

As a result, the interconnection between the folios is tighter due to the complementary sewing, while the paper spine is free from stress as it is detached from the text block (fig. 10). The covers have an adhered directional link across the spine, under the sewing. The use of perpendicular grain direction on the reinforcement allows the use of thin layers that are barely noticeable and yet very effective. There can be several variations of the same idea, all of them tailored to each case.

Fig. 10. Same book as fig. 8, after conservation. The wrapper expands when opening the book, instead of compressing as it did before conservation and enhances the long-term preservation.

CONCLUSION

The book structure is the skeleton gathering the main parts of a book. Conservation needs to prioritize structural damages whenever handling is a requirement, specifically for disproportioned books. The potential modification of the original structure might be necessary when their damages are severe.

Providing structure can be achieved primarily by selecting the right type of joining: unions that require movement endure more when they are sewn, whereas static areas are stronger when adhered.

Secondly, but also relevant, the choice of materials embodying the skeleton (i.e. grain direction) is also a remarkable structural provider. When strategically applied, they enable lighter but steadier reinforcements.

Movable areas should remain light, devoid of thick adhesive layers.

ACKNOWLEDGMENTS

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Equally valued are the institutions and private collectors who trusted the conservation services from the author and gave their permission to share images of their books: Association of Architects of Catalonia (CoAC), ETSEIB—UPC (Superior Technical Engineering School of Barcelona, Polytechnic University of Catalonia), Historical Archive of Barcelona, Photographic Archive of Barcelona, Public Library of Girona Carles Rahola, as well as many others not displayed in this paper’s images.

The conservators behind the projects discussed in this essay deserve special mention: Tea Borovina, Tereza Kubalová, SeHee Song, Ana Tourais, and many others.

Last, but not the least, I would like to thank Jaume Abril, for his loving support.

NOTES

1. Should magnetic ties (on pocket agendas) also be considered as a third type? Please do contact the author if there’s a relevant gap!
2. In later versions of this structure, two or more layers are sewn (not lined), and the sewing passes through the sections and the covers (and the spine supports, if any).
3. Rolls and concertina bindings appear to consist of a single folio being rolled or folded, but even these structures consist of some adhered or sewn components (Song 2009).

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Abstracts presented during the Book and Paper Group Session

The Chew Kee Store: Preserving the Legacy of the California Cantonese Gold Rush

Jennifer Parson and Kala Conservation

The Chew Kee Store in Fiddletown, California, established during the Gold Rush, was an herbal medicine shop and general store that serviced the Chinese immigrant community and remains a unique material archive of the legacy of Chinese American history. With a main storefront at the entrance and living quarters in the back, it served as a business and home for its residents and gives the visitor a rare glimpse into the lives of early Chinese immigrants to California. It operated as a store until 1913 and was the center of the once vibrant community, the largest Chinese community in California outside San Francisco. The store was occupied continuously until the last Chinese resident in Fiddletown, Jimmy Chow, died in 1965. He kept the store and its contents intact and the building stands today as a time capsule of Cantonese Gold Rush immigrant culture. Over the past 40 years, there has been an ongoing community-initiated effort to preserve the Chew Kee Store building and its contents, now a museum and California historic site. The building is a traditional rammed-earth construction; its thick adobe walls are covered in layers of peeling 19th century newspapers. The rooms are filled with original items from the store and other objects of daily life. The walls and shelves reflect the material culture of a 19th-century Chinese merchant: colorful banners with calligraphy, religious ephemera, calendars, decorative tea boxes, medicine bottles, and account books. Most of these paper-based materials were in a severely deteriorated state. This talk will outline the historic significance of the Chew Kee store, past interventions to restore the building and its contents, and lastly my recent conservation treatment of the varied paper-based materials.

Abstracts presented during the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

LINDA OWEN AND GRACE WALTERS
DISCUSSION GROUP CO-CHAIRS

Art on Paper Discussion Group 2022
In Treatment: Collaborative Conservation

INTRODUCTION

Discussing treatments or treatment issues with colleagues is a crucial and productive component of conservation. As conservators, we may work as the only paper conservator in an institution, or as a sole proprietor in private practice. With the pandemic, even conservators who work in larger labs were working on staggered schedules with limited time on site and consequently had limited interaction. Early in our careers, we often discuss treatments as part of the learning process. As we continue in the profession, we develop our networks of friends and colleagues whom we can call upon when complex situations arise. Getting different perspectives on an issue can be incredibly helpful in forming a treatment approach, dealing with a difficult situation, or when reflecting on past decisions. This discussion group was an opportunity to reengage with each other and our larger community.

The presenters covered a range of topics: from the challenges of unstable materials to the decision of when not to treat and, finally, how to approach a work that has been treated by another conservator.

PRESENTATION SUMMARIES

MICHELLE FACINI
MARK ROTHKO: WATER-BASED PAINT ON CONSTRUCTION PAPER FROM THE 1930S

Facini spoke about a unique group of works on construction paper by Mark Rothko and the treatment and storage challenges associated with them. Her presentation explored the history of the works at the National Gallery of Art (NGA). The NGA has the largest collection of Rothko works, totaling approximately 1100, that includes paintings on canvas, works on paper, and archival materials. The collection was bestowed to the NGA by the artist's foundation in 1986. The Gallery's curators have spent 30 years compiling the online catalog raisonné of Rothko's drawings. Facini worked with conservation scientists to study a core group of the works made using water-based paint on construction paper. They examined the materials and techniques of the artworks, their stability and light sensitivity. Microfading was used to determine the sensitivity of the construction paper supports, and Facini was able to utilize the Artist's Materials Collection housed at the NGA to help characterize the supports and paint. The resulting article is published in volume 5 of *Facture*, a biannual journal published by the NGA.

Early in Rothko's career, in the 1930s, the artist worked in transparent and opaque water-based paints, applying them to colored construction papers. These small, personal works of interior scenes often depicted women and children. Facini commented that while the instability of construction paper was generally known, Rothko nonetheless deliberately chose this support and considered them finished works. Ninety of these works are in the NGA's collection, and five of them are still in their original artist's mounts, dating from the 1930s. These mounts are very rare, making them an important part of the work's history and evidence of the artist's intent. Facini raised the issue of conservators being asked to remove mounts and the careful consideration required to determine if it is appropriate to remove or retain an artist's mounting. The remaining five Rothko mounts consist of a window mat with brown paper tape adhering the work to the mat. Inscriptions and labels are on the verso containing information such as dollar amounts, catalog numbers, and exhibition labels.

Condition issues such as creases, tears, losses, and stains are indicative of the inherently unstable materials Rothko used for both the mounts and the artworks. The construction paper has noticeably shifted in color, and brittleness is

This open discussion took place on May 14, 2022, during the AIC 50th Annual Meeting, May 13–17, 2022, in Los Angeles, CA. The moderators organized and led the discussion and recorded notes. Readers are reminded that the moderators do not necessarily endorse all the comments recorded and that, although every effort was made to record proceedings accurately, further evaluation or research is advised before putting treatment observations into practice.

evident in the numerous splits and losses. Undulations on the paper support complicate complex tears in the image area. The media is also friable and vulnerable.

Facini closed her presentation by enumerating the multiple treatment and storage challenges posed by these works and welcoming suggestions and ideas from the audience. Treating the tears and losses will require an adhesive that will not discolor the construction paper support and a mending material that will not obscure media or support. Humidifying the cockling necessitates a technique that does not overly expand the brittle paper support or cause any color shifts in the discolored construction paper. Needs for the storage mounts include access to the verso, safe handling, and display possibilities. The original mounts should still be accessible for viewing and any over-matting should be made to be easily removable.

Michelle Facini, Senior Paper Conservator, The National Gallery of Art, Washington, DC

JAN BURANDT
IT'S A MIRACLE, DON'T TOUCH IT

Burandt presented several projects that called for significant deliberation, highlighting condition concerns with drawings where a classic treatment intervention was not necessarily the most appropriate. The first example she detailed was a collage by Kurt Schwitters, a 20th-century artist known for producing collages and assemblages from all kinds of found scraps and papers. In preparing a collage for a loan, she was confronted by the many losses, rips, tears, and breaks within the piece. It was impossible to determine the original state of the collage with certainty, so conversations with curators included discussions speculating on the degree of "damage" that was inherent to the collage. A decision had to be made whether or not to minimally stabilize the piece for travel or perform a more invasive treatment. Deconstructing portions of the collage, treating individual paper components, and reassembling the composition would be the most extreme possible action. In the end, it was decided to leave the piece as it was, given the fact that many of the damages were in keeping with the aesthetic of the artist. When viewing the collage in the context of many artworks by Schwitters brought together for the traveling exhibition, it became even more apparent that the distressed appearance of elements of the collage were in keeping with the artist's general working practice. Many of Schwitters' collages had condition issues that could be read as damage if considered in isolation. When considered in the larger oeuvre, however, these were easier to identify as part of the working method of the artist and not necessarily as condition issues warranting treatment intervention. Burandt made the point that one doesn't really know an artist until one sees the body of their work, and she supported this by presenting another example of an artist in the collection, Trisha Brown. Brown is a choreographer who makes drawings with charcoal between their toes while dancing on a large, blank, white sheet of paper. Without knowing the artist's working method, one might assume that tears need to be repaired and creases need to be flattened. However, once the method of creation of the drawing is understood, those stresses and damages to the paper are revealed as evidence of how the piece was made, and the conservator's decision-making process shifts. These two examples underlined how knowledge of the artist's working method can make a difference in treatment determinations.

The second example Burandt presented was a drawing by an artist close to the first curator of the Menil Collection, Walter Hopps. The piece incorporated an overlay of transparentized paper with rips and tears that slope forward towards the glazing. When it was prepared for exhibition many years ago, a decision was made collaboratively between the director, the curator, and a paper conservator to mitigate a tear that was believed to have expanded past its initial length. The conservator selectively mended a portion of the tear to what was believed to be its original length. However, the artist's estate saw the piece while on exhibit and felt that the repair wasn't appropriate, so the conservator reversed the treatment after the close of the exhibition, after close consultation. Burandt made the point that even when collaborative discussions are held between people who know the artist and their work quite well, there are still discussions that can be held with the artist's estates or, better yet, the artist themselves. This work was deliberated upon, sensitively cared for when the repairs were made, and later sensitively and successfully reversed. The result is a piece where there is no question that it is now as the artist intended it.

The third example Burandt highlighted was a Robert Gober drawing that was a gift to the Menil Collection. The drawing, a simple graphite line drawing, exhibited some adhesive residue across the top corners of the recto of the drawing and at the center of the verso. A curator requested that the adhesive staining be removed from the front of the drawing. Burandt's assessment was that, given the provenance of the work, the tape application was undoubtedly done by the artist himself. Her concern with the adhesive residue was less that the residue on the recto corners was distracting, and more that there was potential for staining to migrate through the drawing sheet from the passage in the center of the verso, within the image area. Therefore, she mechanically reduced the adhesive residue on the verso but left the adhesive on the recto in place. Subsequently, Robert Gober came and sat for an Artist Documentation Program (ADP) interview at the Menil Collection. This program endeavors to interview living artists about the materiality and intention of the works that they have produced. This program lives online and has transcripts and clips from these interviews available for scholars. During the interview, Burandt showed Gober the drawing, and he said, "Yes, you can tell that this drawing was important to me. I had to keep it close to me. It shows the fingerprint of the artist, and it really shouldn't be removed." This statement affirmed that the adhesive residues were actually indicative of the intrinsic value of this piece to the artist who made it.

Another example Burandt shared was a watercolor made by William T. Williams. This piece was part of an early art loan program that the de Menil family ran and had also been part of the De Luxe show, a groundbreaking exhibition in the 1970s that showcased African-American artists alongside other prominent contemporary artists of the time. Burandt said that she was shocked when she saw an original photograph of the work, as the colors and vibrancy of the piece had dramatically faded. In 2022, Williams returned to Houston for an anniversary of the De Luxe show and came to the Menil Collection to be interviewed for the ADP. Burandt showed him, somewhat hesitantly, the extent of fading of this particular drawing. To her delight, he stated that the media is in fact not watercolor, but aniline dye, and this result was what was intended. His selection of materials at the time was intentional and with full knowledge of the fugitive qualities of these materials. Williams even said that now, only after the fading, did the piece reach its potential as an artwork. Artist interviews like these can be an extraordinary asset to decision making and understanding the full context of works before deciding how and to what level to intervene.

Burandt closed with a couple of treatments to pose to the audience for discussion. The first was a drawing made by Unica Zürn, an artist who had a lot of trauma in her life and created this particular piece while institutionalized. During her life, she also destroyed a lot of her own work, including this piece. Her husband, Hans Bellmer, an artist in his own right, found this drawing destroyed and put it back together again, albeit clumsily. The question she posed was: if the artist destroyed it, should we exhibit it at all? If we exhibit it, should we accept the repair of an untrained, unpracticed artist? Or should we take apart the repairs and re-mend it in a more sensitive way? The curator's opinion was to leave it as it is, as the historical value of the artist's husband reassembling the work is significant. The last treatment presented to the audience is a drawing in name only, as it is actually more of a sculpture. It is made of very thin tissue that is adhered like a drum over a three-dimensional armature. The piece is sealed, so there is no way to access the back of the drawing. Breaks within the suspended paper are lengthy, irregular, and in some areas covered with a matte, loosely bound medium. Someone in the past had bluntly repaired some similar tears with square patches. In contemplating the goal of repairing these new damages to the work in a more sensitive manner, the structure of the artwork as a whole defines the problem. Access to the verso of the paper requiring repair would be impossible without extremely invasive measures. She ended by asking the audience if anyone has any tips or thoughts on the best way to go about accessing and mitigating these damages.

Jan Burandt, Conservator of Works of Art on Paper, The Menil Collection, Houston, TX

KAREN ZUKOR
STEPPING UP/STEPPING BACK

Zukor discussed the challenges of interacting with clients who bring in a work that has been previously treated by another conservator. The situation can be especially problematic if the owner is not happy with the results, or if the treatment was incomplete. There is additionally the difficulty posed when little documentation is provided to the owner, either prior to or after treatment.

Zukor noted that, while these situations are infrequent, she has had to devise a protocol to deal with them.

The first step is to ask the client if there are before-and-after images of the artwork and if she can contact the other conservator to discuss the treatment and potentially access their documentation. Zukor stressed that she would never attempt to treat a work without knowing what had been previously done. The client may present an incomplete version of events, and it is crucial to find out as much information as possible while maintaining respect for one's colleagues. Often, the interaction can end without further treatment, but it is important to make sure that the work is stable. Zukor underlined the importance of not assuming a colleague did something wrong because one cannot really know what occurred—the work may have been damaged in transport or in the interim. Critical questions are: how long ago was the work treated? How has it been stored? How has it been framed or housed since the piece was returned?

Zukor offered a personal example of a client who had commissioned a successful treatment of a large print. The print was placed in a temporary portfolio with acid-free tissue and sandwiched between corrugated cardboard. It was clearly communicated to the client that this was a temporary package for local transport and not a permanent storage solution. However, ten years later the client returned with the print, still in the cardboard housing. The client had forgotten about it under a bed, and the print was now discolored from the cardboard. Zukor re-treated the work, but from then on placed large warning labels on all travel packaging stating "TEMPORARY PACKAGE: not for long-term storage." That phrase is also written on the final invoice/documentation that goes to the owner.

In conclusion, Zukor reiterated the importance of not making assumptions and trying to obtain as much information as possible in a non-accusatory manner. If possible, it is best

to try contacting the other conservator before adopting a critical view and certainly before proceeding with any additional treatment. As she said, “Better to assume a neutral position!”
Karen Zukor, Paper Conservator in Private Practice, Owner, Zukor Art Conservation, Oakland, CA

DISCUSSION SUMMARY

The discussion portion of the session consisted of several audience members offering comments, asking follow-up questions, and expressing solidarity with the issues the presenters faced.

For Facini, questions were posed about the parameters of the treatment: the sensitivity of the media, the location of the tear, etc. A conservator offered the idea of 3D printing a support for the piece, which would allow mending without flattening. Facini asked the audience about their experiences with nanocellulose as a repair material. Several members responded and offered their insights, including the difference in the nanocellulose film’s properties once toning media is added, and the strength (or lack thereof) of a mend made with the material. Others brought up the possibility of using funori as weak adhesive or the use of solvent-set tissues. Using single fibers to bridge the tear was also suggested. The use of fiber-reactive dyes for mending tissues was brought up, and the suggestion was made to reach out to conservators with basketry experience for their expertise. To display the works, double-sided sink mats were discussed. The importance of having open conversations with the curator about what is actually achievable in this instance was also raised.

In response to Burandt’s presentation, several conservators had suggestions for the last work presented. Comments covered using a suction table to gently pull the pieces into alignment while working on the object upside down and employing Japanese screen mending techniques with Klucel, if the work is not sensitive to ethanol. Some discussion focused on the Unica Zürn piece and supported the idea of nonintervention; one suggestion proposed mitigating the appearance of the repairs made by the artist’s husband with gallery lighting. The repairs are now part of the piece and its history, even if it was not the artist’s intent.

In response to Zukor’s topic, many conservators stood up and relayed their own experiences with previously treated items and how they responded to the situation. On the whole, most responded they also tried to contact the previous conservator, and they have learned over the years to always inquire about framer involvement. The discussion concluded with many conservators agreeing on the need to respect colleagues and allied professionals.

ACKNOWLEDGMENTS

The Art on Paper Discussion Group co-chairs would like to thank the presenters and attendees for making the return to an in-person discussion so engaging and successful. They would also like to thank BPG Program Chair Katie Mullen and Assistant Program Chair Morgan Browning for their assistance in organizing the session.

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DISCUSSION GROUP CO-CHAIRS

Library and Archives Conservation Discussion Group 2022 Reparations, Restitution, and Post-Custodial Realities in the Library and Archive: What Is Conservation's Role?

INTRODUCTION

The Library and Archives Conservation Discussion Group (LACDG) held its first in-person meeting presentation and open discussion session during AIC's 50th Annual Meeting in Los Angeles, California. The theme, "Reparations, Restitution, and Post-Custodial Realities in the Library and Archive" was inspired by current events and aimed to explore questions around conservation's role when working with collections appropriated through conquest, theft, and/or colonialism. To provide a springboard for the open discussion, a panel of three speakers gave short presentations that included an overview of protocols for working with Native American archival materials, the post-custodial archival approach to collections, and two case studies involving repatriated library materials. An engaging open discussion with the audience and speakers followed the talks.

SUMMARY OF PRESENTATIONS

JO ANNE MARTINEZ-KILGORE
PROTOCOLS FOR NATIVE AMERICAN ARCHIVAL MATERIALS

The First Archivist Circle developed the *Protocols for Native American Archival Materials* in 2006 with the following aims:

- Inform archives professionals as they manage, preserve, and provide access to Native American materials and content
- Provide guidance and tools to establish collaboration with Native American communities with a foundation of mutual respect
- Set standards to find a balance between the goals of collecting institutions to provide access and the imperative of native cultures to protect their cultural patrimony
- Reframe the understanding of collections to incorporate Native American perspectives.

Conservators and archivists share a basic responsibility to identify, preserve, and understand Native American materials appropriately.
Jo Anne Martinez-Kilgore, Conservator, Arizona State Library, Archives, & Public Records

ERIN HAMMEKE
POST-CUSTODIAL LIBRARY AND ARCHIVES CONSERVATION

A post-custodial or non-custodial approach to collecting may be adopted for a variety of reasons. The lack of diverse representation in many institutional collections, combined with well-justified trust issues between some source communities and memory institutions, logistical challenges, and also changing views of custody in general, have all prompted an interest in exploring post-custodial practices. This talk explored the current landscape of post-custodial archival collections by presenting examples from a spectrum of custodial arrangements found in large- to small-scale archival projects and collaborations. It concluded by offering references for more information and further research.
Erin Hammeke, Senior Conservator for Special Collections, Duke University Libraries

CONSUELA (CHELA) METZGER
REPATRIATION IN ACADEMIC LIBRARIES: TWO RECENT CONSERVATION EXPERIENCES

In the last two years at UCLA Library, two European groups looked in Hathi Trust and found library stamps

Summary of discussion groups at the Book and Paper Group Session, AIC's 50th Annual Meeting, May 13–18, 2022, Los Angeles, California

on books from libraries looted and closed by the Nazis. These library stamps from looted and closed libraries were found on materials in UCLA Library circulating collections. Conservation was asked to evaluate the books and potentially repair the damage. Conservation services that could "mitigate" or "erase" marks of UCLA ownership were casually offered to the European groups requesting the books without first consulting with Conservation. Conservation in both cases noted that this would cause damage to the books and would make provenance history unclear. The first repatriation incident did not involve subject specialists, and the single book was examined by conservation and returned to Europe with no fanfare. The second incident involved subject specialists from the beginning and the group in Europe requested six titles returned. The second incident involved conservation, cataloging, selectors from Judaica and Hebraica, imaging services, and two embassies. The second repatriation event generated a symposium on repatriation issues.[1] As collections are fully available in digital form, those looking for library materials from collections looted by the Nazis may find the materials in US academic libraries. Is there a way we can collaborate internationally in a proactive way? Should academic library conservation departments put policies in place for the treatment of materials to be repatriated?
Consuela (Chela) Metzger, Head of Preservation & Conservation, UCLA Libraries

SUMMARY OF DISCUSSION BY CONSUELA (CHELA) METZGER

Because two of the speakers, Consuela (Chela) Metzger and Jo-Anne Kilgore-Martinez, were there in person, most of the questions were directed to them. There was a clear interest in the excellent presentation Erin Hammeke gave on trends in non-custodial collecting, and there were many requests for her references, which are shared in the "further reading" section at the end of this summary.

A few statements from the discussion group participants pertained to all three talks. There was a statement that these talks all focused on the code of ethics and that ethics is an important theme to keep revisiting. There were several statements on the underlying capitalist and colonial ideas of ownership that have influenced American libraries, museums, and archives. There was a statement that the kinds of thinking expressed in the talks were in some ways piecemeal, and a more structurally appropriate and radical endpoint could be to fully empower communities to take complete responsibility for their materials, and in a sense, erase ourselves as experts and gatekeepers. Other participants noted that outreach and advocacy were an essential part of conservation work. On the related topic of the provenance of archeological materials, a conservator who handles papyrus collections noted that no treatment work should be done on any materials related to archeological excavations, and library and archive conservators need to learn more about provenance issues in general, and there is a new and very useful area in the AIC Wiki devoted to the topic.

Questions and statements related to "Repatriation in Academic Libraries, Two Recent Conservation Experiences" for Consuela (Chela) Metzger

There were several questions about legal issues, specifically if the speaker had contacted their university's legal counsel about the material being repatriated. The speaker noted that these repatriation efforts to date had not involved lawyers and were taken care of librarian-to-librarian, perhaps because the materials were circulating collection materials.

There were questions about how the repatriation path differed depending on who was the first point of contact at the library for the repatriation process. Since the UCLA Library to date does not have one designated person to handle repatriation requests, those different paths through the system may continue. However, at this point, Hebraica and Judaica librarians are actively looking for library stamps on materials that show European Jewish ownership in order to repatriate those materials. One person asked about sharing any past conservation treatment with the original owner. Since these were circulating collection materials, no treatment documentation existed.

There was a question about any religious restrictions on handling the Jewish materials. The speaker was not able to address this question as the materials they presented on were academic, not sacred.

There was a question about the digitization of these repatriated books. Since the rightful custodians in Europe found their material with their library stamps by looking at digitized library material online, these books are all available online in HathiTrust and other repositories.

There were questions about permissions for conservators to talk about repatriation publicly, and the speaker noted that a conference was happening at UCLA Library concurrently with AIC on the topic of the repatriation, and all involved were collaborating.

There was a question about taking a published digitized book out of the public digital domain if requested, and the speaker thought that could be a complex request for a public institution.

One participant questioned the UCLA Library's use of the Benin Bronzes as a visual in their advertising for a repatriation conference—was it appropriate to equate the return of the Bronzes to the return of published library books stolen by the Nazis? The participant charged AIC with making careful distinctions between Repatriation, Restitution, and other issues of social justice and collections.

Questions and statements related to Protocols for Native American Materials for Jo Anne Martinez-Kilgore

There was a question about the problems of enacting the *Protocols for Native American Materials* in a State Archive setting, where budget and oversight are so tied to state government. The speakers said that in some cases state archivists had assumed the materials were just dry records, and not subject to the *Protocols*, but there may be more complexity than they realize, and she urged those in state archives to be knowledgeable about those complexities. The speaker was concerned that the More Product Less Process (MPLP) push in many archives could make attention to content details that the *Protocols* require controversial. There was a concern about ownership of materials in state archives and how state ownership mapped with tribal ownership. The speaker noted that the *Protocols* for archives were written in 2006 and adopted in 2018, so not all archives are as familiar with them as they might need to be. She pointed to the ongoing goal of the *Protocols* as collaborative communication with Tribes, which was a complex process.

There was a question about any experiences using the *Protocols* in the speaker's work. The speaker noted receiving many phone calls from tribal members working with collections. She helps host an archives summit every year and has worked to get a panel together of Tribal speakers. She noted there was lots of room for growth in working with the *Protocols*.

There was a question from a conservator at a regional center who wondered about ownership/*Protocols* issues for treating the "incorporating" documents of towns that may have originally involved Tribal members in their "incorporation." Who "owns" these documents? Was there a place on the AIC website to help guide library and archives conservators when faced with ownership issues that may touch on *Protocols*? The speaker thought some portal on AIC for the *Protocols* could be a good idea. She notes her ideas of being "content neutral" had changed over time and changed how she approached treatments.

There was a question about collections that are a mix of archival documents and 3D objects related to Tribal life. The speaker notes that the School of Advanced Research Guidelines are fairly specific on *Protocols* for objects, and the bedrock of all work with these materials is building relationships and mutual respect.

There was a question about an institutional conservator's role in limiting or refusing to allow Tribal members today to physically use institutionally held Tribal materials for ceremonies. The speaker noted that she did not work in an archive with objects. She reminded the audience all the tribes have their own different relationship with objects in institutions, and if curators and librarians were uninformed or actively discouraging Tribal relationships to their materials, conservators may need to be advocates and allies with the Tribes, if appropriate, but this needs to be on a tribe by tribe basis.

ACKNOWLEDGMENTS

The co-chairs wish to extend their thanks to all the speakers for generously sharing their insights and experiences. They also want to thank the audience for their thoughtful questions and comments during the session. Special thanks to Katie Mullen, BPG Program Chair, and Morgan Browning, BPG Assistant Program Chair, for their support as we developed this program.

NOTE

1. More information on this symposium can be found at https://guides.library.ucla.edu/repatriationsymposium

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Brain-Tanned Leather for Bookbinding: History, Use, and Identification

INTRODUCTION

While researching an 1805 American frontier journal at the Missouri Historical Society, one member of this research team noted the particular qualities of the leather used to form the journal's wrapper. Unlike most vegetable-tanned skin, it was pliable and soft and had a suede surface. Considering the journal's provenance and context of historical production, brain-tanned leather seemed likely.

A search for supporting evidence and other examples brought this research group of four book conservators together. All members of the group were aware of this method of skin processing but were uncertain about the prevalence of the technique in bookbinding or possible identification methods. The use of brain-tanned leather has been well documented in various contexts of material production, but its prevalence within the history of bookbinding was unclear and understudied.

Catalog descriptions of bookbindings frequently conflate the type of animal skin, the manufacturing technique, and the function of that skin in the book structure. For example, leather from deer skin has been associated with chemises on medieval bindings. These outer wrappers are frequently described as "buckskin" or "deerskin" and assumed to be manufactured through brain tanning or fat tanning. The Appendix lists several examples of books with catalog records with unclear language. One aim of this study is to interrogate the presumptions upon which bookbindings are ascribed to certain animal skins and techniques.

Through examination of examples of confirmed or suspected brain-tanned or fat-tanned animal skins used in bookbinding, this study sought to establish the historical and geographic circumstances of use, to define physical characteristics, and to establish a set of visual identification techniques.

This independent submission was developed from a poster presented at AIC's 50th Annual Meeting, May 13–17, 2022, Los Angeles, CA.

METHODOLOGY

This study focused on visual examination techniques as a means of identifying brain-tanned skin. Because advanced analytical equipment is often unavailable in libraries and archives, this study sought to establish parameters of identification that are practical to carry out with the equipment that many library conservation departments already have on hand.

HISTORY AND USE

Rubbing animal fat into hides is thought to be the oldest method of making leather, and one of the earliest written descriptions is found in Homer:

> *As when some master tanner*
> *gives his crews the hide of a huge bull for stretching,*
> *the beast's skin soaked in grease and the men grab hold,*
> *bracing round in a broad circle, tugging, stretching hard*
> *till the skin's oils go dripping out as the grease sinks in*
> – *The Iliad, Book XVII*

Brains as a source of fat for tanning has a deeper prehistory, and its use has been documented in Southern Europe, Scandinavia, Japan, Mongolia, Southern Africa, and North America. Similar to other fat and oil tanning techniques, it produces soft, stretchy skins that are suitable for making clothing, shelter, and bags. Brain tanning requires minimal tools and materials, and skins can be processed in several days, rather than the weeks or months required for vegetable or alum tawing. It is, however, very labor intensive, and was never adapted to industrial production (Richards 2004, 18–25).

In Europe, the practice of brain tanning seems to have been largely supplanted by vegetable tanning and alum tawing before the Western codex was adopted (Cameron 2011, 85–87), and European bookbinding traditions were developed using vegetable-tanned skins, parchment, and alum-tawed skins. The production of durable books usually required access to at least one of these as a covering material. It remains an open question whether any medieval European bookbindings used brain-tanned skins. Some bookbinding elements, like chemises, thong supports, and overcovers were made from soft skins that are clearly not vegetable tanned. However, these books were made in communities with access to other techniques for producing soft leathers, such as alum tawing and oil tanning (Lévêque et al. 2021). The tanning and tawing of naturally soft skins, like deerskin and fine goatskin (including the original chamois goat), is also well documented (Reed 1972, 165–167; Kite and Thomson 2006, 15).

In contrast, brain tanning was widespread among Native American nations until the mid-19th century. Prepared skins were a common item of trade between European colonists and Native Americans. Deerskins, both processed and raw, were a major export item, usually for use in buckskin clothing (Richards 2004, 20–25).

Animal skin coverings on books prior to 1900 are almost always vegetable-tanned leather, parchment, or alum-tawed skin. But, the same characteristics of being a soft, flexible, and strong sheet material, coupled with widespread availability in certain contexts, suggests that brain-tanned skins may be found at least occasionally. Because its use is unexpected, this material is likely to be underidentified or misidentified.

The authors found a few references to the possibility of brain-tanned skin in bookbindings, but no cited historical examples. Perhaps least helpfully, a 1945 guide to the conservation of books mentions the possibility of encountering skins made by "primitive peoples" and blithely instructs the caretaker to humidify, apply leather dressings, and mend tears with "any good leather cement" (Lydenberg and Archer 1945, 75–76). In her study of early American bindings, Julia Miller notes that some sewing supports that are described as being alum tawed may be brain tanned, as the material and knowledge of this manufacturing technique was available to early immigrants (2013, 272). A broader claim is made in a history of St. Louis, Missouri, where the author suggests a significant trade in brain-tanned deerskins brought to France for bookbinding:

> *Between 1772 and 1775, St. Louisans shipped 625,000 pounds of furs to New Orleans, including 215,000 pounds of shaved and brain-tanned (dressed) deer leather and over 133,000 pounds of raw deerskins, when prices for them soared in France but soured in England. La Rochelle developed a booming market for book-binding with deer leather, and many a gentleman's library in fashionable France featured the "works" of Osage women along the "savage" frontier of Missouri. (Fausz 2011, 150)*

Robert Espinosa refers to more recent use in his 1983 article on conservation rebinding, where he mentions as a footnote his interest in using brain-tanned skins as a substitute for vegetable-tanned or alum-tawed skin. And finally, a number of book artists have created bindings using brain-tanned skin, including works by Pamela Spitzmueller and Jim Croft (Yerkes 2006, 39; GBW 2021, 21).

HOW IT WAS MADE

Information on how brain-tanned skins were made is based on modern interpretation since there is little written historical information about the process. It is likely, however, that the fundamental steps are unchanged. The process of making brain-tanned skins includes the following, summarized from Richards (2004) and Nurse (2012):

Fleshing. The first step in the process is to scrape the flesh (underside) of the skin to remove fat and membrane. This is often done with the skin draped over a pole or beam with the flesh side up. The skin is then scraped with a draw knife or similar tool to remove the membrane.

Alkalizing (also referred to as bucking). The scraped skin is alkalized. Traditionally this was likely done by soaking the skin in a wood ash and water solution. This step further removes organic matter like mucus that would inhibit the penetration of the tanning oils found in the brain mixture.

Graining. Graining is one of the more distinctive steps in brain tanning. The epidermis and grain of the skin is removed by scraping, which allows for better penetration by the tanning agents. Since vegetable-tanned leathers do not require this step, the removal of the grain layer is one possible indicator of a brain-tanned skin.

Rinsing. After graining, rinsing removes the alkaline agents introduced earlier. Traditionally this step probably would have been done in running water, such as a stream. Modern approaches in still water are often facilitated with the introduction of weak acids, such as vinegar. Weak acids may also be introduced at this stage to impart a softer finish to the skin.

Membraning. This step is a second scrape of the flesh side to remove any last remainders of the membrane.

Wringing. Excess moisture is removed from the skin by twisting and squeezing.

Dressing. The dressing is the introduction of the brain matter. The brain is mixed with water until a soupy consistency is achieved, then additional water is added until there is sufficient quantity to allow the skin to soak. After wringing out, the steps are often repeated to ensure proper saturation with the fats.

Softening. Softening is achieved through physical manipulation of the skin.

Smoking. Smoking introduces aldehydes and ensures that the skin can be wetted out and dried repeatedly. It also imparts the tan, yellow, or brown color often associated with “buckskin” leathers.

Skin preservation techniques are messy, both in process and categorization. The precise steps in brain tanning vary by community and tanner, and similar results can be achieved by substituting soap or other fats for brains. The same step can also be used in different tanning techniques, and vegetable-tanned and alum-tawed skins are also “dressed” to lubricate and soften the skin. Almost any available fat has been used for this step, including brains, livers, egg yolks, tallow, butter, and milk.

FINDING IT IN OUR COLLECTIONS

Brain-tanned skin is likely to be unidentified or misidentified in descriptions of bookbindings. When seeking potential examples in library catalogs, contextual clues and related search terms from the following categories may be helpful:

- Soft, flexible skins: tawed, alum tawed, chemise, reversed leather, reversed skin, suede, limp.
- Related preservation processes: oil tanned, chamois, fat tanned, smoke tanned, buckskin, organ tanned.
- Species-related terms: deerskin, buckskin, doeskin, elk skin, bison, buffalo.

While this project did identify examples of books that incorporate brain-tanned elements, these are more likely to be singular exceptions than part of any “book binding tradition.” Brain-tanned elements are most likely to be found outside of mainstream European bookbinding practice. These books might be found in circumstances analogous to the North American examples discussed below, i.e. books bound in communities that produced brain-tanned skins, or by people in a close trading relationship with those communities.

The authors encourage conservators and curators to more fully describe these materials to aid in their identification and to work towards a clear and consistent terminology. As conservators and curators bring the use of brain-tanned skins in bookbinding to light and find better ways to describe them in catalogs, they may also be in a position to improve how Native American nations, places, and relationships are described. This can include correcting inaccurate or harmful descriptions in catalog records or can include bringing to light connections that were ignored or marginalized. Some resources that the authors have found useful include the Native Governance Center (nativegov.org) and the National Museum of the American Indian (americanindian.si.edu).

PHYSICAL AND VISUAL CHARACTERISTICS

The appearance of a skin is influenced by many factors, including the species of animal, its age, added color, how it was used, and its degradation over time. Some of these aspects correlate with the method of tannage and can be used in the identification of brain-tanned skins. For example, there are many objects that incorporate brain-tanned bison, deer, and elk skin, but not so many that use brain-tanned calf, sheep, or goat skin.

As noted above, the initial preparation of skins for brain tanning usually (but not always) includes removing the grain layer to allow the oils to fully penetrate the skin. Brain-tanned skins are initially quite stretchy and easily deformed. Cut edges do not maintain 90 degree angles, and slits can be pulled into soft, round holes (Emmerich Kamper 2020, 203–206).

Although both vegetable-tanned and brain-tanned skins can be dyed or painted to be a variety of colors, most vegetable tannins impart a medium brown, dark brown, or reddish color. Brain tanning initially produces skins that are off-white. Subsequent smoking can impart a variety of yellow, cream, gray, or light brown colors. Therefore, a dark brown, grain-on calfskin with crisp cut edges is unlikely to have been brain tanned, while a light brown skin with grain missing, soft edges, and stretched out areas from use, might be brain tanned (fig. 1).

Further examination under UV illumination can support the identification of brain tanning. Raw skins naturally fluoresce under UV illumination, and most preservation methods do not eliminate that fluorescence. Accordingly, rawhide, parchment, alum-tawed, urine-tanned, and brain-tanned skins all fluoresce. Vegetable tannins, however, strongly

Fig. 1. Samples of brain-tanned, alum-tawed, chrome-tanned, and vegetable-tanned skins under normal illumination. Note the suede surface texture and lack of grain layer in the brain-tanned samples.

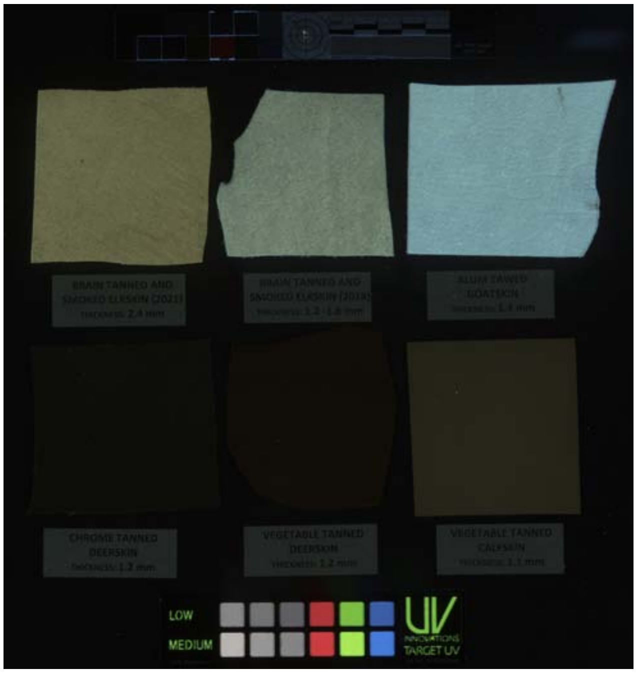

Fig. 2. The same samples as figure 1. Under UV illumination, brain-tanned and alum-tawed skins fluoresce, while chrome- and vegetable-tanned skins do not.

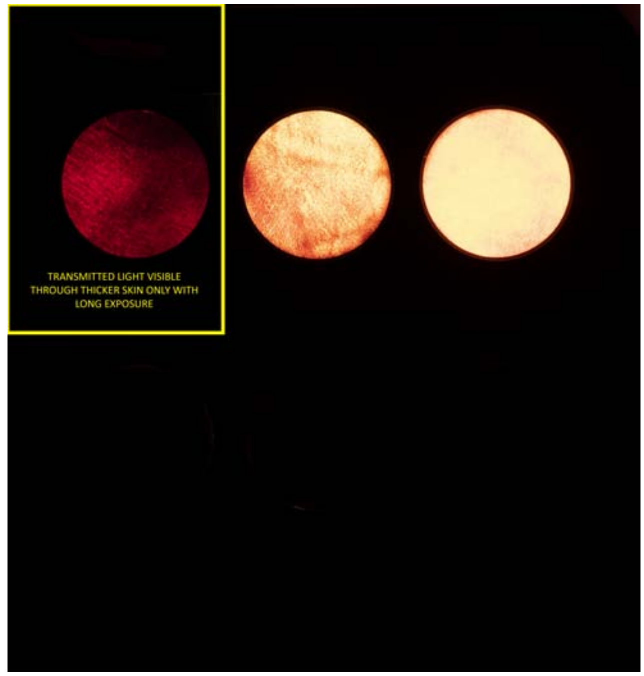

Fig. 3. The same samples as figure 1. Brain-tanned and alum-tawed skins allow transmitted light to pass, while chrome- and vegetable-tanned skins do not.

quench fluorescence, so a vegetable-tanned skin will appear almost black under UV illumination (fig. 2). Skins that have been dyed or painted with tannin-based colors will also appear black on the surface, though some fluorescence may be visible in cross section or abraded areas. Chrome tannage also quenches fluorescence (Reed 1972, 252–256), and the authors have observed that some modern leather dyes have a similar quenching effect.

In limp bindings, transmitted light can also help with identification. In strong transmitted light, rawhide, parchment, alum-tawed, urine-tanned, and brain-tanned skins show skin translucency. Vegetable-tanned skins do not. This difference is apparent even on very thick and very thin skins (Emmerich Kamper 2020, 106). The authors did not fully investigate chrome-tanned leather, but in the few examples they examined, no translucency was observed (fig. 3). For on-site inspection of books, the authors used a handheld ultraviolet lamp with 365nm 6 watt bulbs and a 350 lumen LED headlamp for transmitted light. For photographing the samples in figures 2 and 3, they used a 365 nm ultraviolet studio lamp and a transmitted light box with a 250 W bulb.

These physical and visual characteristics can suggest or support the identification of brain-tanned skins but do not provide conclusive identification. This evidence can suggest candidates for further analysis or eliminate possibilities from further evaluation. They can also be used to improve catalog records by more accurately describing notable features of a book. For example, a book described as being bound in leather might be more helpfully described as being sewn into a soft animal skin wrapper, possibly buckskin.

IDENTIFICATION OF BRAIN-TANNED SKIN IN BOOKBINDINGS

Armed with the information above, the authors searched for examples in library and archival collections (see table 1). This search was frequently complicated by imprecise catalog descriptions, but examination combined with provenance revealed several clear trends.

For medieval European manuscript books, the search for brain-tanned skins centered on descriptions of the animal origin of the covers. Several dozen books with catalog descriptions related to "deerskin" or "doeskin" were examined but usually led to books with alum-tawed or vegetable-tanned deerskin covers or to books where the animal origin was unclear (or clearly not deer).

One example of a bookbinding that was evaluated is a 12th-century English manuscript in its original binding (MS G.65, Morgan Library & Museum, fig. 4). The manuscript was cataloged as bound in doeskin over wooden boards with a doeskin chemise. The chemise fluoresced under UV illumination. The fluorescence was partially masked by surface dirt and was more apparent at abraded areas and folds. A more recent vegetable-tanned leather repair on the chemise did not fluoresce. Based on the context of production

Institution	Call number or Identifier	Description in catalog leading to examination (e.g. deerskin, doeskin, or buckskin)
Library of Congress	Rosenwald 1	Deerskin
Library of Congress	Rosenwald 5	Giant Bible of Mainz, remnants of a chemise are visible
Library of Congress	Rosenwald 73	Doeskin
Library of Congress	Rosenwald 382	Doeskin
Library of Congress	Incun 1473 .V56 Thacher Coll copy 1	Deerskin
Library of Congress	Incun. 1476 .C36	Deerskin
Library of Congress	KB 90 Incun 1490.V6	Deerskin
Library of Congress	Ms. 209 Medieval and Renaissance Manuscript Coll	Buckskin
Library of Congress	BS1440 .B4 1640 Am Imp	The Bay Psalm Book in a Colonial American binding
Library of Congress	BX9070 .W7	Produced by early American printer Zadok Cramer of Pittsburgh. A number of his books are described as bound in deerskin in historical advertisements.
Library of Congress	F353 .C877	Printed by Zadok Cramer
Library of Congress	F353 .C878	Printed by Zadok Cramer
Library of Congress	F353 .C88	Printed by Zadok Cramer
Library of Congress	F353 .C89	Printed by Zadok Cramer
Library of Congress	F353 .C90	Printed by Zadok Cramer
Library of Congress	F353 .C91	Printed by Zadok Cramer
Library of Congress	F353 .C92	Printed by Zadok Cramer
Library of Congress	F353 .C922	Printed by Zadok Cramer
Library of Congress	F353 .C923	Printed by Zadok Cramer
Library of Congress	F592.5 .G2 1807	Printed by Zadok Cramer
Library of Congress	PS3157.W5 L3	Printed by Zadok Cramer
Library of Congress	Harkness Collection HC-M 2, Box 19A,19B	Sixteenth century Mexican and South American limp leather wrappers
Library of Congress	Kislak Manuscript 1015	Deerskin. Sixteenth century Central American manuscript
Library of Congress	George B. McClellan Journals	Early American journal
Library of Congress	Micajah McGehee journal (MMC-1910)	Early American journal
Library of Congress	Titian Ramsay Peale journals	Early American frontier journal
Library of Congress	Zebulon Montgomery Pike journal	Early American frontier journal
Library of Congress	George Carl Ludwig Preuss diaries (MMC-1959)	Early American frontier journal
Library of Congress	Theodore Talbot journals (MMC-2170)	Early American journal
Library of Congress	George Washington Papers, Series 1, Subseries 1B: Diary, March 11 – April 13, 1748 [New Calendar]	Suggested by curator
Library of Congress	James Wilkinson, Orderly Book, December 20, 1803	Early American frontier journal
Missouri Historical Society Archives	Clark Family Collection, v. 6. Elkskin Journal	Initially examined as part of related research project by team member
Morgan Library & Museum	MS B.28	Deerskin
Morgan Library & Museum	MS G.65	Deerskin and doeskin mentioned. Original binding with chemise
Morgan Library & Museum	MS M.105	Deerskin and doeskin mentioned
Morgan Library & Museum	MS M.123	Deerskin and doeskin mentioned
Morgan Library & Museum	MS M.326	Doeskin

(continues)

Table 1. List of Objects Examined

Institution	Call number or Identifier	Description in catalog leading to examination (e.g. deerskin, doeskin, or buckskin)
Morgan Library & Museum	MS M.631	Deerskin
Morgan Library & Museum	MS M.809	Deerskin
Morgan Library & Museum	MS M.824	Deerskin
Morgan Library & Museum	MS M.891	Deerskin
Morgan Library & Museum	MS M.901	Deerskin
Morgan Library & Museum	MS M.902	Deerskin
Newberry Library	Ayer 3A 540	Book of hymns in Cree described as bound in limp elk skin
Newberry Library	Ayer MS 733	Colonial American journal, Native American connection
Newberry Library	Ayer MS 978	Journal of Joseph Whitehouse, member of Lewis and Clark expedition known for his skill as a tailor with buckskin
Newberry Library	Ayer MS 1240	18th c. Mexican manuscript
Newberry Library	Ayer MS 1480	18th c. Mexican manuscript
Newberry Library	Ayer MS 1485	16th c. Mexican manuscript
Newberry Library	Case MS 93.3	Deerskin
Newberry Library	MS 27	Limp white leather cover
Newberry Library	MS 31	Deerskin
Newberry Library	MS 38	Deerskin
Newberry Library	Ruggles 393	Buckskin. Prayer book in Mohawk language
William L. Clements Library, University of Michigan	C2 1905 My	"Edition limited to five hundred copies ... Bound in Indian smoke tanned buckskin."
William L. Clements Library, University of Michigan	J 1794 Bi	Early American scaleboard binding, thongs described as possibly deerskin

Table 1. List of Objects Examined (*Continued*)

and intact grain layer, the chemise is probably alum tawed. The doeskin over the wooden boards is also likely alum tawed.

A search for handmade, limp leather covers led to the examination of several limp leather bookbindings from the 16th and 18th centuries from Mexico and Central and South America. However, most were bound in dark brown leather with an intact grain layer, and the leather did not fluoresce or allow transmitted light to pass.

Two handmade American journals kept by members of the Lewis and Clark Expedition (1804–1806) were examined under UV illumination and with transmitted light. Both showed fluorescence and allowed light to pass through the thickness of the skin. In combination with their

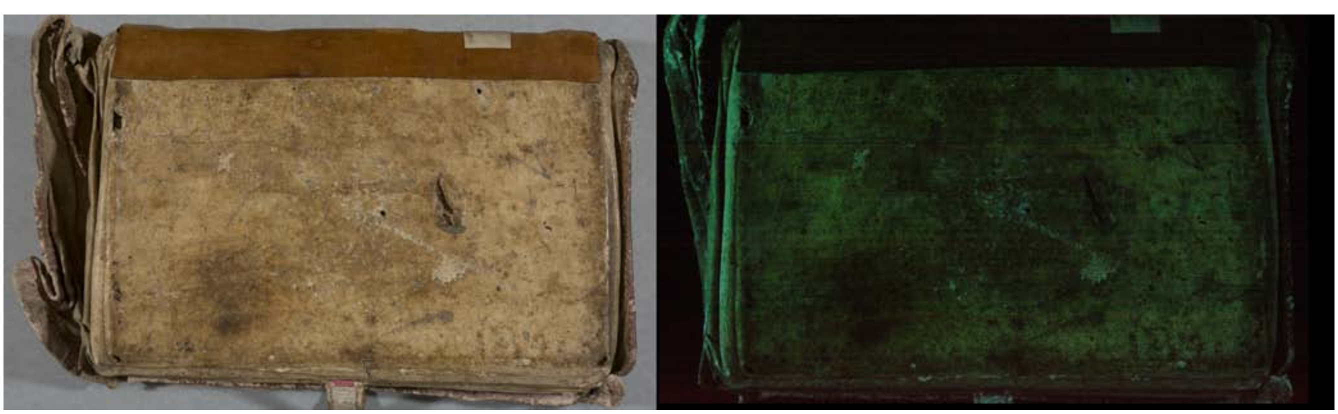

Fig. 4. De Officiis, England, 1150–1199. Courtesy of the Morgan Library & Museum. Normal illumination (left) and UV illumination (right). Fluorescence is partially masked by surface dirt and coloration, and more apparent at abraded areas and folds. More recent vegetable-tanned leather spine repair does not fluoresce at all. Based on context of production and intact grain layer, overcover skin is probably alum tawed.

Fig. 5. William Clark, Elkskin Journal, 1805. Courtesy of the Missouri Historical Society, St. Louis. Normal illumination (left) and detail under UV (right). Soft skin wrapper fluoresces and allows transmitted light to pass. In combination with color, tactile qualities, and a well-documented context of production, this evidence strongly indicates that the journal was bound in brain-tanned skin.

well-documented context of production, color, and tactile qualities, this provided near certainty that they were bound using brain-tanned skin (figs. 5 and 6). An 1841 hymnbook that was printed, bound, and distributed in a remote Canadian mission was also examined. Similar visual qualities and evident interaction with the Cree Nation supported the strong possibility that it had been bound in brain-tanned skin (fig. 7).

Fig. 6. Joseph Whitehouse, Journal Commencing at River Dubois, 1804–1805. Courtesy of the Newberry Library. Normal illumination (left) and detail of skin edge (right). This journal is closely related to the Elkskin Journal. The soft skin wrapper fluoresces, allows transmitted light to pass, and is likely made from brain-tanned skin.

Fig. 7. James Evans, [Hymns, Swampy Indians, their speech], 1841. Courtesy of the Newberry Library. Skin wrapper fluoresces and allows transmitted light to pass. Book was printed, bound, and distributed in a remote Canadian mission and was likely made with a brain-tanned skin wrapper.

A 1905 printed volume about frontier and pioneer life bears a note on its half-title that reads “Edition limited to five hundred copies. This is Number 285. Bound in Indian smoke tanned buckskin.” Upon examination, this binding material appeared to have a soft surface texture without a grain layer, soft-cut edges, and an overall light brown color; it showed fluorescence under UV illumination. The subject matter and edition note suggested that the use of brain-tanned skin is likely (fig. 8).

FUTURE RESEARCH

This study demonstrated that visual and physical characteristics can support the identification of brain-tanned skins but not conclusively identify it. Further research would seek to confirm suspected examples of brain-tanned skin through analytical testing.

When sampling is possible, microchemical spot testing can usually differentiate brain tanning from visually similar techniques such as alum, smoke, or oil tanning. To identify alum-tawed skin, the sample is treated with a solution of aluminon (aurintricarboxylic acid ammonium salt); if the sample turns bright pink, the presence of aluminum is confirmed. To confirm that a skin has been brain, smoke, or oil tanned, the sample is treated with a hydroxylamine dye and heated; a bright yellow-green fluorescence confirms the presence of aldehydes, which are a marker of brain, smoke, and oil tanning. Brain-tanned skin can be differentiated from smoke or oil tanned skin by repeating the test on a positive sample.

Fig. 8. Herbert Myrick, *Cache la poudre: the Romance of a Tenderfoot in the Days of Custer*, New York, 1905. Courtesy of the William L. Clements Library, University of Michigan. Limited edition advertised as being “Bound in Indian Smoke Tanned Buckskin.” Surface texture, flexibility of cut fringe, and fluorescence under UV (right) supports identification of brain-tanned skin.

If the sample still fluoresces upon the second round of testing, it is likely to have been brain tanned (Kite and Thomson 2006, 59; Pouliot and Kaplan 2012).

Biomolecular analysis may also prove useful. At present, several research groups are investigating the use of techniques like mass spectrometry and peptide mass fingerprinting to identify brain tannage and confirm the animal species of skins (Popowich 2022; Lévêque et al. 2021).

Limited analytical testing of leather samples was done at the Library of Congress in support of this research. Although preliminary, this confirmed the work of other researchers (Pouliot, Mass, and Kaplan 2015) showing that XRF was not a useful technique for distinguishing brain-tanned from alum-tawed skins. UV-induced visible fluorescence imaging indicated differences in the fluorescent emissions of an alum-tawed and a brain-tanned skin; further exploration of UV spectroscopy may reveal systematic differences in the wavelengths of the observed UV-induced fluorescence.

This study did not attempt to assess the long-term stability of brain-tanned skin or provide conservation advice. The authors suggest that conservators and curators review recent literature on conserving skins from allied conservation fields (Howatt-Krahn 1987; CCI 1992; Kite and Thomson 2006).

CONCLUSION

By combining visual examination with provenance information, this study established that brain-tanned skins were used for bookbinding within the context of North American book production with connections to Native American communities. Books described in catalogs as being bound in deerskin or even buckskin in a medieval European context were not shown to be brain tanned using the cited methodology. The classification of deerskin, doeskin, or buckskin in medieval bindings should be understood as a description of the physical qualities of a skin, rather than an indicator of skin species or method of skin preparation.

The authors hope that, by raising awareness of the use of this material in bookbindings, custodians of book collections will gain a better understanding of the context in which brain-tanned leather bookbindings were created and that the methodology discussed will assist in creating ever more accurate bookbinding descriptions in collection catalogs.

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GLOSSARY

The following glossary is offered as a starting point for understanding terms used to describe the referenced materials and is compiled from Waterer (1946, 158–170) and Emmerich Kamper (2020, 231–235).

Brain Tan: a variety of fat/oil tan that uses brains as the tanning agent.

Buckskin: 1) A processed skin, usually deer, that has been fleshed and then "bucked," or soaked in an alkaline solution prior to fat/oil tanning. 2) In more modern usage: a deerskin leather prepared by oil or alum tannage and with a suede finish. Used principally for clothing, gloves and footwear.

Chamois: Originally referred to genuine chamois goat pelts that had been oil tanned (or "shamoyed"). Later the term was applied to other oil tanned skins, principally sheepskin.

Doeskin: This term can refer to the prepared skin of a female deer, or in more modern usage, to a washable gloving leather prepared from sheep or lamb skins, usually the flesh split, mostly by the oil process but sometimes by the formaldehyde method.

Fat/Oil Tan: A tanning method that uses emulsified lipids (fats and oils) to produce a soft leather. A wide variety of lipids have been used, including animal fat, brains, bone marrow, liver, milk, butter, and egg yolks.

Oil Tan: A tanning method that uses oils which oxidize at low temperature (usually marine oils like cod oil, whale oil, and seal oil) as the tanning agent.

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