The Book and Paper Group ANNUAL

VOLUME THIRTY-SIX 2017

The American Institute for Conservation of Historic and Artistic Works

The Book and Paper Group of the
American Institute for Conservation of Historic and Artistic Works

2017

Chair
WHITNEY BAKER

Program Chair
DEBRA CUOCO

Assistant Program Chair
JENNIFER JOHNSON

Secretary/Treasurer
SARAH NORRIS

2017–2018 Publications Committee

WHITNEY BAKER, BRUCE BUMBARGER, GWENANNE EDWARDS, MICHELLE FACINI (EMERITUS), ELIZA GILLIGAN (EMERITUS), HENRY HEBERT (CHAIR), JUSTIN JOHNSON, KATHERINE KELLY, SARAH REIDELL (EMERITUS), DENISE STOCKMAN, AMY BAKER WILLIAMS

FOR OLIVIA PRIMANIS

The Book and Paper Group (BPG) and the conservation community owe a debt of gratitude to Olivia Primanis, who recently stepped down from the BPG Publications Committee (PubComm) after 20 years of volunteer service. Her peers share this dedication to thank her for her positive spirit, expansive curiosity, and boundless enthusiasm, which have enriched the conservation community. Olivia began her career as a bookbinder and since 1990 has been the senior book conservator at the Harry Ransom Humanities Research Center at the University of Texas in Austin. She has played a fundamental role in PubComm and served the committee in almost every conceivable capacity, most recently as chair (2011–2014) and chair emeritus (2014–2017). During her tenure, the committee grew in breadth and depth to now include printing and distributing the *Book and Paper Group Annual,* building a robust Wiki for both book and paper conservation topics, and maintaining a dynamic website that is the envy of other specialty groups. Her enthusiasm for the distribution of our combined knowledge buoyed long-term PubComm projects, such as the comprehensive remastering project started in 2013 to convert legacy analog and digital images and text for PDF delivery of the entire *Annual* back-catalog. Another crucial project that formed under her was a *Book Conservation Catalog* to match the renowned *Paper Conservation Catalog,* both now the basis for the BPG content that is free to all on the AIC wiki. Olivia's most pivotal contribution to our field may yet be her work as a mentor and colleague to countless interns and volunteers from around the world who now fill the ranks of our field. The Publications Committee thanks Olivia and wishes her well in her next endeavors!

THE BOOK AND PAPER GROUP

ANNUAL

VOLUME 36 2017

Papers presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28–June 2, 2017, Chicago, Illinois

Challenging the Myths Surrounding Paul Gauguin's "Little Marvels"
MARY BROADWAY AND HARRIET K. STRATIS . . . 7

Ionic Fixatives for Water-Sensitive Media
SOYEON CHOI. . . . 12

Re-engineering Broken Book Spines (abstract)
JANA DAMBROGIO, AYAKO LETIZIA, MARY UTHUPPURU, BRIEN BEIDLER, KATE BEATTIE, AND EMILY HISHTA COHEN . . . 17

Oil on Paper: A Collaborative Conservation Challenge
HOLLY HERRO, SCOTT NOLLEY, WENDY COWAN, AND KRISTI WRIGHT . . . 18

Treatment 305: A Love Story
KATHY LECHUGA. . . . 28

Reducing Agent Tert-Butylamine Borane Complex and Its Use in Stain Reduction on Paper-based Artifacts (abstract)
CRYSTAL MAITLAND . . . 40

Medium-rare: An Innovative Treatment Approach to the Space between General and Special Collections
QUINN MORGAN FERRIS . . . 41

Recapturing the Subtleties
ADAM NOVAK AND DARIA KEYNAN . . . 52

The Story Not Told: The Examination and Treatment of Edward Steichen's Oochens (abstract)
LINDA OWEN AND KATHRYN MORALES . . . 58

The Challenge of Scale Revisited: Lessons Learned from Treatment and Mounting an Exhibition of 160 Illuminated Manuscripts
ALAN PUGLIA AND DEBORA D. MAYER . . . 59

Sidewalks, Circles, and Stars: Reviving the Legacy of Sari Dienes
SAMANTHA SHEESLEY . . . 69

Line Up, Back to Back: Restoration of a Korean Buddhist Sutra in Accordion Book Format
HSIN-CHEN TSAI AND TANYA UYEDA. . . . 75

Papers presented at the Joint Book and Paper + Research and Technical Studies Session, AIC's 45th Annual Meeting, May 28–June 2, 2017, Chicago, Illinois

Lessons from a Large-Scale Survey of Parchment Animal Origin and Production Quality (abstract)
MATTHEW COLLINS. . . . 84

Revisiting Paper pH Determination: 40 Years of Evolving Practice in the Library of Congress Preservation Research and Testing Laboratory (abstract)
CINDY CONNELLY RYAN, MICHELE YOUKET, DR. LYNN BROSTOFF, AND DR. ERIC BREITUNG . . . 85

Centuries of Cellulose: Lessons Learned from the Molecular Size of Cellulose in Naturally Aged Paper Collections (abstract)
DR. ANDREW DAVIS AND DR. FENELLA FRANCE. . . . 86

Characterization of the Aniline Dyes in the Colored Papers of José Posada's Prints Using Time-of-Flight Secondary Ion Mass Spectrometry to aid in Developing a Treatment Protocol for the Removal of Pressure-sensitive Tapes
STACEY M. KELLY, JODIE UTTER, AMY V. WALKER, PHD, ASHLEY A. ELLSWORTH, PHD, AND JENNY K. HEDLUND 87

Contacts that Leave Traces: Investigation into the Contamination of Paper Surfaces from Handling (abstract)
KARIN VAN DER PAL, SIMON W. LEWIS, WILHELM VAN BRONSWIJK, DR. RACHEL S. POPELKA-FILCOFF, AND DR. GREGORY D. SMITH. 101

The Codex Eyckensis (8th Century): Re-evaluation of the 20th Century Restoration and Conservation Treatments (abstract)
DR. LIEVE WATTEEUW, MARINA VAN BOS, AND BRUNO VANDERMEULEN 102

Papers presented at the General Session, AIC's 45th Annual Meeting, May 28–June 2, 2017, Chicago, Illinois

Henri Matisse's The Swimming Pool: Conservation and Exhibition
KARL BUCHBERG. 103

Nanocellulose Films: Properties, Development, and New Applications for Translucent and Transparent Artworks and Documents
REMY DREYFUSS-DESEIGNE 108

Summaries of discussion groups at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28–June 2, 2017, Chicago, Illinois

Art on Paper Discussion Group 2017 Multiple Perspectives on the Treatment of Multiples: Innovative Thinking on the Conservation of Prints
RACHEL FREEMAN, CYNTIA KARNES, AND HARRIET K. STRATIS DISCUSSION GROUP CO-CHAIRS 115

Library Collections Conservation Discussion Group 2017 Unexpectedly Expert: Diversifying Your Skills to Cover All the Bases
ANGELA ANDRES, SONYA BARRON, AND ANAHIT CAMPBELL DISCUSSION GROUP CO-CHAIRS 128

Independent Submissions

Less of You, More of My Ancestors: The Conservation Treatment of Polynesian Barkcloth
J. M. IACCHEI 136

Exploring New Glass Technology for the Glazing of Papyri
MARIEKA KAYE. 150

The Book and Paper Group Annual

Managing Editor
GWENANNE EDWARDS
Library of Congress
Washington, DC

Assistant Editor
JUSTIN P. JOHNSON
University of Washington Libraries
Seattle, WA

Editorial Office: bpgannual@gmail.com

Online Version: www.conservation-us.org/bookandpaper

The *Book and Paper Group Annual* is published once each year in print format by the Book and Paper Group (BPG), a specialty group of the American Institute for Conservation of Historic and Artistic Works (AIC).

The *Annual* is distributed as a benefit of membership to those who were members of the BPG in the date year of the issue. Additional copies or back issues are available from AIC. All correspondence concerning subscriptions, memberships, back issues, and address changes should be addressed to:

American Institute for Conservation of Historic and Artistic Works
727 15th Street NW, Suite 500
Washington, DC 20005
info@conservation-us.org www.conservation-us.org

The *Book and Paper Group Annual* is a non-juried publication. Papers presented at the Book and Paper Session of the annual meeting of the American Institute for Conservation of Historic and Artistic Works are selected by committee based on abstracts. After presentation authors have the opportunity to revise their papers before submitting them for publication in the *Annual*; there is no further selection review of these papers. Independent submissions are published at the discretion of the BPG Publications Committee. Authors are responsible for the content and accuracy of their submissions and for the methods and/or materials they present. Publication in the *Annual* does not constitute official statements or endorsement by the BPG or by AIC.

Volume 36 Copyright © 2017
The Book and Paper Group
American Institute for Conservation of Historic and Artistic Works
All rights reserved by the individual authors

ISSN 0887–8978
Printed in the United States of America by Edwards Brothers, Inc.

The paper used in this publication meets the minimum requirements of ANSI/NISO Z39.48–1992,
American National Standard for Permanence of Paper for Publications and Documents in Libraries and Archives.

MARY BROADWAY AND HARRIET K. STRATIS

Challenging the Myths Surrounding Paul Gauguin's "Little Marvels"

ABSTRACT

Most conservators have at one time or another been regaled with alluring tales of an artist's "muted palette," the "golden" patina imparted to prints and drawings by their underlying sheet tone, accumulated grime or discoloration, or the importance ascribed to a particular paper's "idiosyncratic undulations" or "enhanced texture." In these romanticized accounts, the effects of aging are recast as conscious artistic choices bolstered by theoretical aesthetic underpinnings that ignore evidence that is often to the contrary. It is far more likely that these beloved works may well have appeared brighter, whiter, flatter, and stain free when they left the artist's hands.

Sometimes canonized art historical descriptions can take on mythic proportions and propagate misinterpretation simply because they do not take into consideration the current understanding of an artist's materials and techniques, their inherent aging, or the outright damage sustained by works of art. Only in recent decades has there been a new effort in art historical scholarship to situate artworks within the continuum of time and space, and to consider their physical properties as organic and inorganic materials that alter with age, light exposure, and, intended or not, mishandling. Several graphic works within Paul Gauguin's production have been misread in the past. However, when the artist's biography, influences, motives, and materials are examined holistically, a new dimension can emerge that adds to the understanding of the artworks and the aesthetic motivations that underlie their production.

At the Art Institute of Chicago, research was carried out over four years for a scholarly, online, and interactive catalog of the museum's formidable holdings of nine paintings, a ceramic, and more than 200 graphic works.[1] A variety of analytical techniques were used from the most rudimentary, such as transmitted light, raking light, UV, and infrared examinations, to the most sophisticated, such as scanning XRF to locate and identify various pigments, FTIR and surface-enhanced Raman spectroscopy (SERS) to identify dyes, and gas chromatography mass spectroscopy (GC-MS) to identify binders in the inks and paints, as well as photometric stereo for surface shape studies carried out in collaboration with scientists at Northwestern University (Cossairt et al. 2015). By focusing specifically on the artist's complex practice, the understanding of a restless, innovative spirit, known among friends and foes alike as a tinkerer, a *bricoleur*, or a jack-of-all-trades, who integrated the making of ceramics, woodblock prints, wood-carved furniture, decorative objects, and friezes into his practice, side by side with painting, has been furthered.

THE *NOA NOA SUITE* PRINTS

When Gauguin returned from his first voyage to Tahiti in 1893, he took a small studio in Paris, where he painted the walls and windows bright chrome yellow, and there, in addition to painting in oils, he printed woodblock matrices by hand without a press to produce his famed *Noa Noa Suite*—a series of 10 woodblock prints that he made with the intent to illustrate his manuscript of the same name (Stratis 2016a). The artist's graphic production embraced the printing of dozens of "unique multiples." No two prints pulled from the same matrix were ever alike. Gauguin's goal was not to produce a uniform edition but several visually distinct prints from the same matrix, deliberately obscuring the very same imagery that he had so meticulously and painstakingly carved into the block, thereby allowing chance and randomness to play an extremely important role in his process.

From this scientific investigation, it has become apparent that what has been described in the art historical literature as the "relative colorlessness" of the prints, as one scholar put it, is not a result of the artist's intentions but rather the selective fading and chemical alteration of certain dyes and pigments, as well as the discoloration of paper supports. Pigment analysis carried out using XRF and SERS identified cadmium yellow and a cochineal lake as two of the primary examples of such fugitive media. Ultramarine blue was also identified and is known to be a pigment that is susceptible to alteration in an acidic environment. Using this information, a

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

handful of works were digitally recolorized, which effectively restored their narratives and linked them more closely to the artist's paintings. Many works on paper were clearly meant to illustrate similar scenes painted in oils that are appreciated for their vibrant colors to this day.

MANAO TUPAPAU AND ITS MATRIX

Although Gauguin experimented constantly and reused imagery interchangeably between art forms, his repertoire of images remained quite static over a period of two decades. However, his experiments with disparate media to represent identical imagery in new and different ways was constantly in flux. Throughout his career, Gauguin sought to eliminate distinctions between art and craft; for him, the making of ceramics, wood carvings, and prints was equal to painting and sculpture.

As research progressed, the relationship between the artist's wood-carved three-dimensional tikis, his decorative friezes, and his printing matrices became more and more apparent. Although it was difficult, if not impossible, to convince several art historians that there is indeed a direct correlation between Gauguin's carving of decorative friezes and printing matrices in the physical context of his studio practice, the discovery of the block for *Manao tupapau* in a Swiss private collection makes the relationship all the more

Fig. 1. (a) Paul Gauguin, *Manao tupapau* (*She Thinks of the Ghost* or *The Ghost Thinks of Her*), 1894-1895. Woodblock frieze; 22.5 x 52.5 x 5 cm. Private collection. (b) Paul Gauguin, *Manao tupapau* (*She Thinks of the Ghost* or *The Ghost Thinks of Her*), 1894-1895. Woodblock print in black ink with brush and stencil-applied red, orange, yellow, green, blue, violet, and brown watercolors on ivory Japanese paper, laid down on cream Japanese paper; 227 x 522 mm (image), 232 x 572 mm (sheet). The Art Institute of Chicago, John H. Wrenn Fund, 1946.341.

tangible. After Gauguin successfully printed a small number of impressions from the block, he returned to it with tools in hand to carve it more deeply and transform it into a bas-relief (Gamboni 2016; Stratis and Perlman 2017) (fig. 1).

BLOCKS FOR THE *SUITE OF LATE WOODBLOCK PRINTS*

Gauguin's use of discarded and indigenous wood also informed his production, especially after his final relocation to Tahiti in 1895. His *Suite of Late Woodblock Prints* is an innovative tour-de-force in this regard. Many of the surviving matrices from the group reveal their common origins when their grain patterns and contours are flipped, rotated, and placed adjacent to one another, as in *Te atua* and *The Rape of Europa* (Stratis 2016c, 2017b) (fig. 2).

By examining multiple impressions of prints from the *Suite*, it was determined that in *Ox Cart* and *Wayward Shrine in Brittany*, striations from the edge of the saw are similar, and *Eve*, *Buddha*, and *Human Misery* all share a contiguous grain pattern indicative of their common source (Stratis 2016b). In the art historical literature, it has always been assumed that the *Suite* contained 14 prints; however, careful study of Gauguin's methods to make his blocks, and comparison of their overall contours and grain patterns as displayed in the prints, reveals that the *Suite* included 15, not 14, prints.

TRANSFER DRAWINGS

The transfer drawings[2] Gauguin made in Tahiti and the Marquesas toward the end of his life fascinated art historians and conservators alike and warranted closer study (fig. 3,

Fig. 2. Top left: Paul Gauguin, woodblock matrix for *Te atua (The God)*, 1898-1899. Polynesian teak wood, irregular; 24.1 x 28.6 cm. Private collection. From Druick, D., and P. Zegers. 1995. *Paul Gauguin: Pages from the Pacific*. Auckland, New Zealand: Auckland City Art Gallery. 54. Top right: Paul Gauguin, woodblock matrix for *The Rape of Europa*, 1898-1899. 24 x 23 x 4 cm. Museum of Fine Arts, Boston, Harriet Otis Cruft Fund, 36.624. When one of the blocks is flipped and rotated 180°, the two mirror each other. Bottom left: Paul Gauguin, printed by Luc Guérin, *Te atua* (*The God*), from the *Suite of Late Woodblock* Prints, 1898-1899, printed 1995. Woodblock print in black and brown ink from two blocks on cream Japanese paper with cream fibrous inclusions throughout; 244 x 227 mm (image); 500 x 335 mm (sheet, sight). The Art Institute of Chicago, gift of Gilles Artur and Jean-Pierre Zingg, 1995.373. Bottom right: Paul Gauguin, *The Rape of Europa*, 1898-1899. Woodblock print in black ink on ivory Japanese paper, laid face down on ivory wove paper; 231 x 205 mm (image and sheet). The Art Institute of Chicago, Print Sales Miscellaneous Fund, 1949.934.

Fig. 3. Left: Paul Gauguin, *Nativity (Mother and Child Surrounded by Five Figures)*, 1902. Transfer drawing in brown and black ink on cream wove paper, trimmed and perimeter mounted on cream laid paper (recto); 244 x 221 mm. The Art Institute of Chicago, gift of Robert Allerton, 1922.4317. Right: Detail of Gauguin's *Nativity* illustrating the linear voids in the foreground figures.

left). To do so, photometric stereo techniques to more accurately visualize the drawings' surfaces were developed in partnership with scientists in the Department of Electrical Engineering and Computer Science at Northwestern University. Gauguin's own words written in 1900 were used as a starting point (Gauguin et al. 1943): "I have just done a series of experiments in drawings with which I am fairly well pleased . . . It looks like a print, but it isn't. I used a thick ink instead of pencil, that's all."

Added to this was art historian Richard Field's insightful 1973 working hypothesis that explained that the "ghost lines" (fig. 3, right) in many transfer drawings were caused by residual indentations in the paper from previous drawings. But in fact, for his more ambitious transfer drawings, Gauguin's process was much more complex and involved several steps. Photometric stereo revealed that there were no indentations in the papers themselves, so the lines had to have been created by some other means. This, it turns out, involved the transfer of ink from a piece of glass from which some of the ink had been removed in a previous transfer (Cossairt et al. 2015; Stratis 2017a).

THE EXHIBITION

The curatorial/conservation partnership that began with work for the online scholarly catalog revolved around a mutual fascination with Gauguin's materials and his artistic process. When research began, there was no way to know that the findings of these investigations would come to shape *Paul Gauguin: Artist as Alchemist*, an exhibition that emphasizes the materiality of the artworks presented. Gauguin appropriated objects, worked in multiple media, and created a unique visual vocabulary that relied as much upon chance as it did an intuitive, yet firm, grasp of the potential in the assorted materials that he gathered to make art.

LITTLE MARVELS

When trying to come up with a clever title for this paper, the beautifully poetic statement penned by Gauguin's dealer, Ambroise Vollard, was selected. He wrote, "It was a fact that Gauguin turned everything that fell into his hands—clay, wood, metal and so forth—into little marvels."

This quote comes from the English translation of Vollard's 1936 autobiography *Recollections of a Picture Dealer*. It is a much-cited statement, having appeared in monographs and exhibition catalogs for decades. However, when attempting to confirm the primary reference for the quote, it seems that the English translator took some liberties, adding the sentence that was quoted here—without any direct reference to Vollard whatsoever. And sadly, when returning to the original French text, no version of this statement is anywhere to be found. Despite disappointment, the quote continued to be embraced regardless of who uttered it. Gauguin left us a legacy of "little marvels" that continue to fascinate and perplex both the casual viewer and those who are determined to untangle the complexities of their making and materiality. Therefore, please forgive this inadvertent perpetuation of yet another myth.

ACKNOWLEDGMENTS

The success of this study is a result of the collaborative and innovative spirit of scientists Céline Daher, at the Centre de

Recherche sur la Conservation des Collections (CRCC) in Paris; Oliver Cossairt, Xiang Huang, Aggelos Katsaggelos, and Jack Tumblin, at Northwestern University's Department of Electrical Engineering and Computer Science; Marc Walton, at Northwestern University and Northwestern University/Art Institute of Chicago Center for Scientific Studies in the Arts (NU-ACCESS); and Francesca Casadio and Kenneth Sutherland at the Art Institute of Chicago.

NOTES

1. To access the online scholarly catalog, visit https://publications.artic.edu/gauguin/reader/gauguinart/section/139805.
2. To view a didactic video explaining Gauguin's transfer drawing process, visit https://vimeo.com/221656549/55ac5574b0. Other processes featured in the exhibition *Gauguin: Artist as Alchemist* can be accessed at the following sites: https://vimeo.com/221656467/77ee96d00a, https://vimeo.com/221656512/c080214a36, https://vimeo.com/221656617/b594e8f7a1.

REFERENCES

Cossairt, O., X. Huang, N. Matsuda, H. Stratis, M. Broadway, J. Tumblin, G. Bearman, E. Doehne, A. Katsaggelos, and M. Walton. 2015. Surface shape studies of the art of Paul Gauguin. In *Proceedings of the 2015 Digital Heritage International Conference, Volume 2*, eds. G. Guidi, J. C. Torres, R. Scopigno, and H. Graf. Los Alamitos, CA: Institute of Electrical and Electronics Engineers. 13-20.

Gamboni, D. 2016. Cat. 77, *Manao tupapau*: Commentary. In *Gauguin paintings, sculpture, and graphic works at the Art Institute of Chicago*, eds. G. Groom and G. Westerby. Chicago, IL: Art Institute of Chicago.

Gauguin, P., J. Rewald, A. Vollard, and A. Fontainas. 1943. *Paul Gauguin: Letters to Ambroise Vollard & André Fontainas*. San Francisco: Grabhorn Press. 31-32.

Stratis, H. K. 2016a. Cats. 51–60, *The Noa Noa Suite*, 1893/94: Technical study. In *Gauguin paintings, sculpture, and graphic works at the Art Institute of Chicago*, eds. G. Groom and G. Westerby. Chicago, IL: Art Institute of Chicago.

Stratis, H. K. 2016b. Cats. 93, 94, 95, 100, 101, the *Suite of Late Woodblock Prints* 1898/99: Technical study. In *Gauguin paintings, sculpture, and graphic works at the Art Institute of Chicago*, eds. G. Groom and G. Westerby. Chicago, IL: Art Institute of Chicago.

Stratis, H. K. 2016c. Graphic ingenuity: Gauguin's later printmaking innovations: Technical overview; Cats. 102, 103, the *Suite of Late Woodblock Prints* 1898/99: Technical study. In *Gauguin paintings, sculpture, and graphic works at the Art Institute of Chicago*, eds. G. Groom and G. Westerby. Chicago, IL: Art Institute of Chicago.

Stratis, H. K. 2017a. Disrupting convention: Gauguin's unique multiples and transfers. In *Gauguin: Artist as alchemist*, ed. G. Groom. New Haven, CT: Yale University Press. 42-43.

Stratis, H. K. 2017b. Unique iterations. In *Gauguin: Artist as alchemist*, ed. G. Groom. New Haven, CT: Yale University Press. 304-305.

Stratis, H. K., and A. Perlman. 2017. Day of the god. In *Gauguin: Artist as alchemist*, ed. G. Groom. New Haven, CT: Yale University Press. 260, 264-265.

MARY BROADWAY
Associate Paper Conservator
Art Institute of Chicago
Chicago, IL
mbroadway@artic.edu

HARRIET K. STRATIS
Former Senior Research Conservator, Art Institute of Chicago
Stratis Fine Art Conservation LLC
Chicago, IL
harriet@stratisartconservation.com
hkstratis@gmail.com

SOYEON CHOI

Ionic Fixatives for Water-Sensitive Media

INTRODUCTION

Originally an industrial product used in textile and paper dyeing processes, ionic fixatives were introduced in paper conservation in the 1980s with the intent of preserving the legibility of dye-based inscriptions during aqueous treatment of archival and library materials (Bredereck and Siller-Grabenstein 1988).

Ionic fixatives can form almost water-insoluble complexes with oppositely charged dyes. Although ionic fixatives can be far more effective in fixing dye-based inks that are otherwise hardly fixable with conventional film-forming fixatives, they also present potential problems. Ionic fixatives may change the hue and saturation of the ink, fix paper discoloration itself, cause uneven washing of paper if applied locally, and leave chemical residue behind (the side effects of which are largely unrecorded). A recent scientific study revealed that the Bückeburg fixative solution may cause not only undesirable paper discoloration but also cellulose damage, especially in the current operational method of omitting a rinsing step (Roller et al. 2015). The same study showed that the ionic charge of the paper is changed through ionic fixative treatment.

This study explores various ionic fixatives that are currently available in the U.S., compares them for their effectiveness and aging characteristics, and finds a selection of fixatives causing relatively fewer side effects. The limitation of this study is that all test results were evaluated only by visual examination before and after aging without any molecular level analysis of the cellulose. Therefore, it is suggested to limit the application of the findings of this study only to circumstances where the benefit of using them outweighs the potential side effects, and when the application area is small enough to avoid possible weakening of the paper.

Thirteen different fixatives were gathered for this study. Twelve of them were obtained from Archroma (a branch of Clariant) and BASF between 2013 and 2015, and one of them (the mixture of Mesitol NBS and Rewin EL) was obtained from Neschen in the early 2000s. Given the possible impact of shelf life, test results with the Neschen fixative should come with a disclaimer. The fixatives tested and their basic characteristics are summarized in the Appendix.

ACCELERATED AGING TESTS

Each fixative was diluted to 5% in deionized water (except the Neschen fixative, which was used without dilution) and, using a cotton swab, was applied in an approximately 1 in. diameter circular shape onto four strips of Whatman filter paper #1. The samples were then left to air-dry. One strip was kept as a control sample, one was aged in an accelerated aging chamber without washing, one was washed for 15 minutes and set aside without accelerated aging, and one was washed for 15 minutes and then aged in the chamber. The accelerated aging condition was set for 70°C and 50%RH for 96 days. After aging, the samples were examined side by side, under normal light and under UV light.

When examined under normal light (fig. 1), the unwashed samples developed noticeable discolorations after accelerated aging with three fixatives: Cassofix FRN-300, Catiofast 2345, and Nylofixan HF. When washed, with the exception of Nylofixan HF, most of the fixatives performed well, causing little to no noticeable discoloration in the paper before and after aging. The areas marked in dotted rectangular boxes in figure 1 indicate fixatives that developed visible discoloration.

Examination under UV light showed remarkable fluorescence patterns (fig. 2). The areas marked in dotted rectangular boxes in figure 2 indicate the fixatives that developed noticeable fluorescence. All fixatives tested showed innate fluorescence in varying degrees from faint to moderate as shown in the control samples. When these fixatives were aged without washing, the fluorescence of each intensified. However, the sample washed for 15 minutes showed an overall decrease in fluorescence compared to the control, indicating that the washing process was effective in rinsing out fixatives from the paper. However, when the washed samples were aged, a slight remnant of fluorescence remaining after washing notably intensified, even in those areas that appeared clear after washing. The only fixatives that did not

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

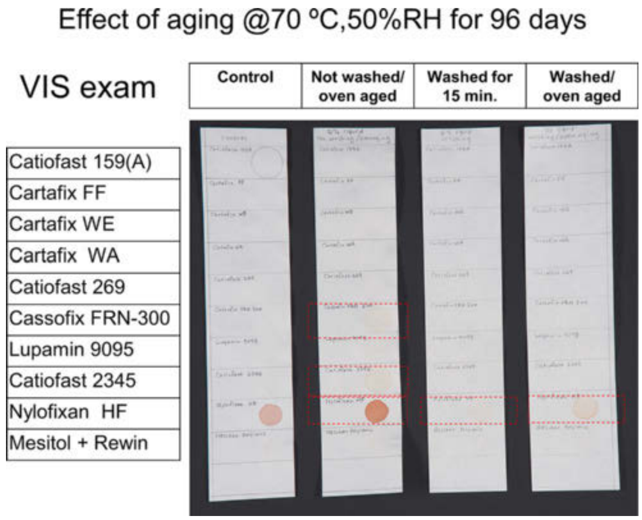


Fig. 1. Effect of aging at 70°C and 50%RH for 96 days, examined under visible light. The red dotted rectangular boxes in the picture indicate where visible discoloration developed.

develop noticeable florescence after aging were Cartafix FF and Catiofast 2345. When tested on actual media, Catiofast 2345 was found to be not effective as a fixative, dispersing any writing media in contact. Therefore, Cartafix FF stood out as being superior to other fixatives in this study in terms of causing the least amount of visible discoloration and UV fluorescence after aging.

In comparison, Cartafix WE showed slight but noticeable UV fluorescence development after accelerated aging. Cartafix WE is synonymous with Sandofix WE. Sandofix WE has been tested extensively (Leroy and Flieder 1993), showing that it did not damage cellulose nor adversely affect colors as long as the samples were sufficiently washed and deacidified. Therefore, it could be inferred that UV fluorescence developed after aging in this study might not necessarily mean that damage had occurred to the cellulose. Observing the degree of fluorescence is only a qualitative tool to gauge the effectiveness of rinsing out these fixatives from paper.

The suspension solution of Mesitol NBS and Rewin EL, also known as the Neschen fixative or Bückeburg fixative, did not perform well in this study, leaving fluorescing residue before and after aging. Mesitol NBS and Rewin EL have been actively used since 1997 as a part of the Bückeburg process. A recent study stated that Rewin EL was the main cause of cellulose damage, but Mesitol NBS did not seem to have any negative effect on cellulose (Roller et al. 2015).

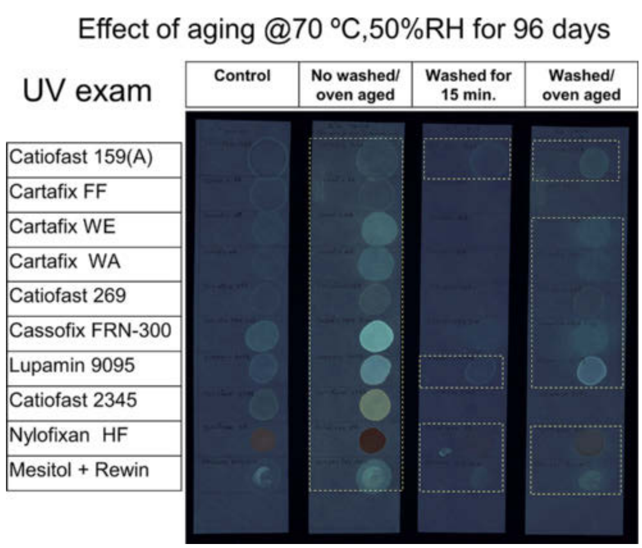


Fig. 2. Effect of aging at 70°C and 50%RH for 96 days, examined under UV light. The white dotted rectangular boxes indicate where noticeable fluorescence developed. UV photo credit: Richard Caspole, Yale Center for British Art.

APPLICATION METHODS

In various published articles on ionic fixatives (Brederick and Siller-Grabenstein 1988; Leroy and Flieder 1993; Blüher et al. 1999; Havlínová et al. 2005; Porto and Shugar 2008), reaction time given for different fixatives varied from 1 to 15 minutes, and the concentration of the fixative used varied from 1.2% to 30%. In this study, all experiments were performed with a 5% concentration both in a solution and in a gel mixture, and the reaction time was approximately 1 to 2 minutes.

When a paper sample was treated overall with an ionic fixative, it was preferable to wash the paper before the fixative completely dried, resulting in less fixative residue left in the paper. The effect of a drying step between the fixative application and washing steps was observed under UV light, which showed that slightly more fluorescing residue remained in the paper if the fixative was allowed to dry on the paper before the washing step.

However, confining the applied fixative only to the media area seemed necessary when applying ionic fixatives to localized areas in heavily discolored paper. Ionic fixatives could fix the paper discoloration itself and cause uneven washing between fixed and unfixed areas. One way to achieve a precise application to a localized area was to apply a fixative solution using a small brush on a suction platen while drying the applied solution with a hair dryer.

Another way to achieve a precise application was to apply the fixative in a mixture with methylcellulose A4M gel. A gel-mixed fixative helped minimize sinking and bleeding of the media during fixative application, especially for the extremely sensitive writing inks, such as felt-tip pen inks and fountain pen inks. A gel-mixed fixative was applied first on the front with a small brush over a suction platen and then on the verso without a suction platen. Subsequently, the object was immersed in a bath for washing. The gel was then gently brushed off in the bath during washing, approximately 1 to 2 minutes after putting the object in the bath. It was observed

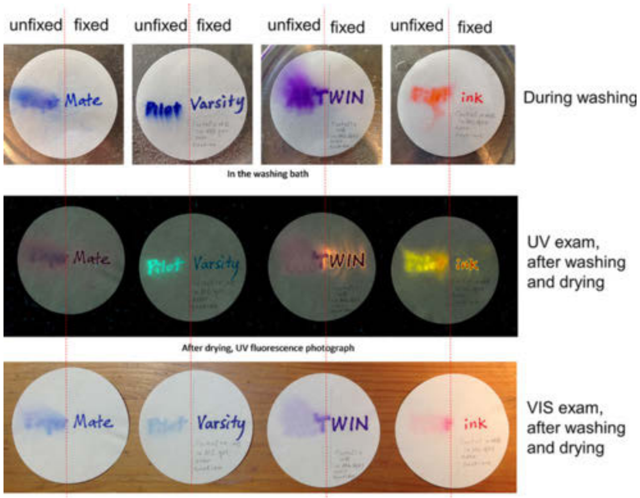


Fig. 3. During and after treatment. Four different pens applied on Whatman filter paper were locally fixed with Cartafix WE 5% concentration mixed in 4% methylcellulose A4M gel applied on the front and the back, and washed in a bath by immersion. Brightly colored fluorescing components in the writing media were partially mobilized during washing, visible under UV light. UV photo: Richard Caspole, Yale Center for British Art.

that if the gel-mixed fixatives were left on the media for too long without washing, the poultice action of the gel would compete with the fixative action; therefore, it was preferable to wash the paper shortly after the fixative gel was applied.

TESTING ON COMMERCIAL PENS AND INKS

Different ionic fixatives mixed with methylcellulose A4M gel were tested on commercial felt-tip pens and fountain pens applied on Whatman filter paper #1. After fixing and immersion washing, the treated samples were examined under visible and UV light (figs. 3, 4). Most of the cationic fixatives worked well preserving the legibility of the pen markings, but not without unavoidable minor changes and losses in color. Some cationic fixatives were slightly better than others in terms of fixing ability. Two anionic fixatives (Appretan N 92100 and Catiofast 2345) and one cationic fixative (Lupamin 9095) failed in action.

Three brands of commercial liquid ink were also tested: Winsor & Newton calligraphy ink for fountain and dip pens, labeled as nonwaterproof and lightfast; Dr. Ph. Martin's Bombay India ink, labeled as waterproof and pigmented; and Higgins dye-based drawing ink, labeled as transparent washes. Blue, green, red, and purple colors were tested for each brand. Each color was applied to Whatman filter paper #1 and air-dried. Each sample was then soaked with a 5% solution of each fixative and washed on a wet blotter to visualize any movement of the ink (fig. 5). The treated samples were organized in groups: control, not fixed and washed, fixed and washed giving acceptable results, and fixed and washed giving unacceptable results (fig. 6). All cationic fixatives performed well for Winsor & Newton calligraphy inks and Dr. Ph. Martin's India inks. Two anionic fixatives, Catiofast 2345 and Appretan N 92100, failed in action. Interestingly, the Higgins dye-based drawing inks could not be fixed by any of the cationic or anionic fixatives tested, suggesting that some components other than the dyes in the inks may inhibit fixative action.

OUTLOOK

Several factors should be considered when deciding to use ionic fixatives. Ionic fixatives permanently alter the composition of the media and the ionic character of paper. Some

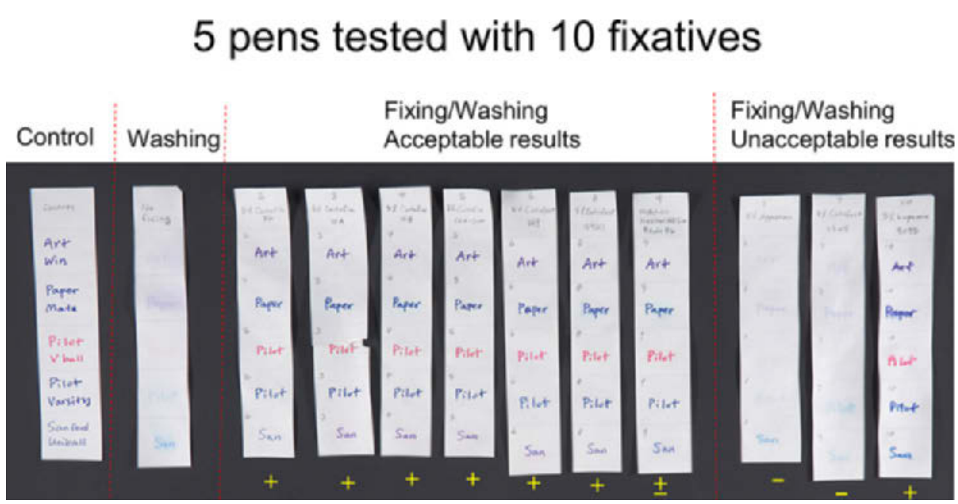


Fig. 4. After treatment. Five different pens applied on Whatman filter paper were locally fixed with 10 different fixatives mixed in methylcellulose A4M gel and then washed in a bath by immersion. The paper strips from left to right indicate control, washed without fixing, washed after fixing with Cartafix FF (+), Cartafix WA (+), Cartafix WE (+), Cassofix FRN-300 (+), Catiofast 269 (+), Catiofast 159(A) (+), a mixture of Mesitol NBS and Rewin EL (– and +), Appretan N 92100 (–), Catiofast 2345 (–), and Lupamin 9095 (+). The plus (+) and minus (–) signs below the paper strips indicate the ion charges of each fixative.

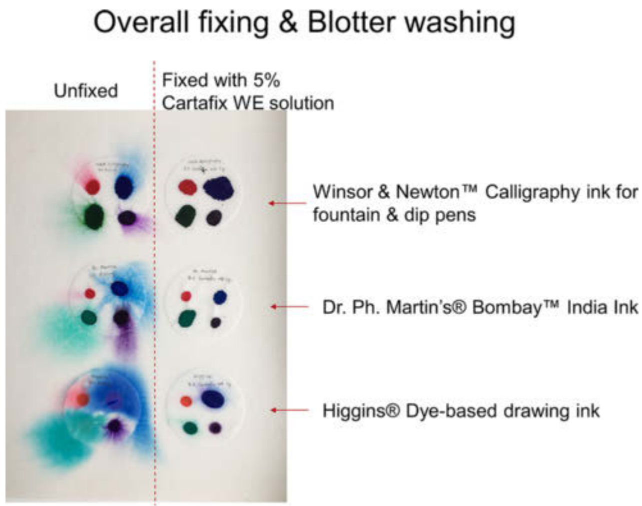


Fig. 5. During treatment. Three different brands of ink applied on Whatman filter paper were fixed overall with Cartafix WE 5% solution and then washed on wet blotter.

degree of change in the hue and saturation of color may occur. Long-term effects on cellulose molecules have not been sufficiently investigated in most of the fixatives mentioned earlier. Sufficiently rinsing the fixative from the object after application is important to minimize possible long-term side effects.

Based on this study, although limited to visual examination only, the author cautiously suggests Cartafix FF, a cationic fixative, as a viable fixative, potentially better than the other tested fixatives in this study, because it developed the least amount of fluorescing residue in the paper after accelerated aging, and it effectively fixed all of the tested media comparably or better than other tested fixatives.

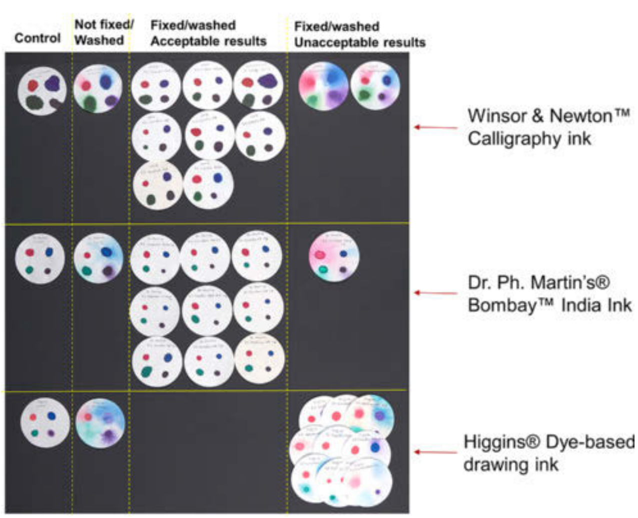


Fig. 6. After treatment. Three different brand inks applied on Whatman filter paper were fixed overall with 10 different fixative solutions and then washed on wet blotter.

Cartafix WE, a cationic fixative synonymous with Sandofix WE, developed slight fluorescence after aging in this study. However, a detailed previous study by Leroy and Flieder (1993) showed that Sandofix WE did not cause cellulose damage or adversely affect the colors. Cartafix WE was versatile to all media tested in this study and therefore may be another viable cationic fixative.

The author could not acquire any effective anionic fixatives for this study. Therefore, the author refers to the recent study by Roller et al. (2015) about the positive properties of Mesitol NBS.

The choice of 5% concentration in all tests in this study could be unnecessarily high. Under lower concentration, a few more fixatives might have shown more promising results in terms of discoloration and fluorescing residues after aging.

ACKNOWLEDGMENTS

I appreciate the generosity of Archroma/Clariant, BASF, and Neschen for providing fixative samples for this study. I would like to thank Dr. Paul Whitmore, Dr. Catherine Stephens, and Dr. Jens Stenger, Institute for the Preservation of Cultural Heritage, Yale University, for providing valuable advice and help with the accelerated aging processes; Professor Joan Irving, Winterthur/University of Delaware Program in Art Conservation, for allowing me to share my experiences with her students; Professor Dr. Irene Brückle, Stuttgart State Academy of Art & Design, for having given me the motivation to study this topic; and Debora Mayer, Helen H. Glaser Conservator, Harvard Weissman Preservation Center, and her staff for giving me the opportunity to share my experience and receive valuable feedback.

REFERENCES

Blüher, A., A. Haberditzl, and T. Wimmer. 1999. Aqueous conservation treatment of 20th century papers containing water-sensitive inks and dyes. *Restaurator* 20 (3-4): 181-197.

Bredereck, K., and A. Siller-Grabenstein. 1988. Fixing of ink dyes as a basis for restoration and preservation techniques in archives. *Restaurator* 9 (3): 113-135.

Havlínová, B, J. Mináriková, L. Švorcová, J. Hanus, and V. Brezová. 2005. Influence of fixatives and deacidification on the stability of arylmethane dyes on paper during the course of accelerated aging. *Restaurator* 26 (1): 1-13.

Leroy, M., and F. Flieder. 1993. The setting of modern inks before restoration treatments. *Restaurator* 14 (3): 131-140.

Porto, S., and A. N. Shugar. 2008. The effectiveness of two cationic fixatives in stabilizing water-sensitive dye-based inks on paper. *Book and Paper Group Annual* 27: 63-69.

Roller, J., A. Pataki, A. Potthast, and I. Brückle. 2015. Aqueous washing treatment aids: How to remove ionic fixatives from paper. *Restaurator* 36 (4): 307-331.

SOURCES OF MATERIALS

Archroma US Inc. (paper and textile division of Clariant)
4000 Monroe Rd.
Charlotte, NC 28205
704-331-7000
BASF Corporation
11501 Steele Creek Rd.
Charlotte, NC 28273
800-346-8590

GSK mbH (previously Neschen)
http://www.gsk-conservation.de/en_index.html

SOYEON CHOI
Head Paper Conservator
Yale Center for British Art
New Haven, CT
soyeon.choi@yale.edu

APPENDIX

Fixing Agents

Name (company)	Ion charge	Chemical information
Suspension of 1.2% Mesitol NBS & 6% Rewin EL (Neschen)	Mix of anionic and cationic	Mesitol NBS: anionic fixative, methylene-linked condensation product of arylsulphonic acids and hydroxyaryl sulphone; brownish powder or brownish liquid Rewin EL: cationic fixative, nitrogen-containing condensation product with formaldehyde
Appretan N 92100 (Archroma/Clariant)	Anionic	Acrylic ester copolymers in aqueous dispersion; self-crosslinking; a coating/binder that is applied on top of dyes/pigments; acts as a barrier to water by cross-linking
Cartafix FF (Archroma/Clariant)	Cationic	Fully condensed polyamine resin; a highly effective cationic colorant fixative in producing colorfast colored tissue, napkin, and toweling grades
Cartafix SWE (Archroma/Clariant)	Cationic	Guanidine, cyano-, polymer with 1,2-ethanediamine, N-(2-aminoethyl)-, hydrochloride salt; auxiliary for the paper and paperboard industry
Cartafix WA (Archroma/Clariant)	Cationic	Cationic methylene guanidine; guanidine, cyano-, polymer with ammonium chloride and formaldehyde
Cartafix WE (Archroma/Clariant)	Cationic	Synonyms for Sandofix WE; methylolamide cationic fixative; textile auxiliary fixing agents; auxiliary for the paper industry
Cassofix FRN-300 (Archroma/Clariant)	Cationic	Amino aldehyde condensate; textile auxiliary chemical; improves colorfastness of cotton, rayon, and blends with synthetic fibers dyed with direct, acid, and reactive dyestuffs
Nylofixan HF (Archroma/Clariant)	Anionic	Anionic arylsulphonate polymer in solution; a fixative used as a posttreatment to dyeing and printing on polyamide fibers and their blends
Catiofast 159(A) (BASF)	Cationic	Polyamine solution polymer; a cationic fixative and deposit control aid for the manufacture of fine paper, newsprint, mechanical specialties, and paperboard grades
Catiofast 269 (BASF)	Cationic	Poly(polydiallyldimethylammonium chloride) liquid solution; a cationic fixative and deposit control aid for the manufacture of fine paper, newsprint, mechanical specialties and paperboard grades
Catiofast 2345 (BASF)	Anionic	Polyacrylate polymer solution; a deposit control aid for the manufacture of fine paper, newsprint, mechanical specialties, and paperboard grades
Lupamin 9095 (BASF)	Cationic	Copolymer of vinylformamide/vinylamine in an aqueous solution
Polymin PR 971 L (BASF)	Cationic	Water-soluble, high molecular weight polyethylenimine; retention and drainage aid for the manufacture of all paper and board grades; fixing agent for fillers, fines, pitch (wood and white), anionic and nonionic colloids, pigment dyes, and direct dyes

Re-engineering Broken Book Spines

Books provide a unique set of considerations for the conservator, as they seek to preserve not only the volume's historic record but in most cases also its functionality. Often the fragility of the historic materials makes it difficult to maintain function without sacrificing the object's history, limiting a future researcher's ability to ask and answer certain questions. Thus, employing a treatment that can improve a book's accessibility while protecting its physical historic record is ideal. For more than 50 years, variations of a spine reback have been the primary option to repair books and their spine covers. The technique is effective but invasive, requiring the conservator to lift or remove original components to anchor newly added repair materials. The treatment we propose is an innovation in book repair that will offer conservators an alternative. Originally developed by Jana Dambrogio more than 15 years ago while studying and conserving two large and diverse historic collections, this treatment is tailored for books with broken spines or detached boards. The Re-engineering Broken Book Spines (RBBS) research group, formed 2 years ago, performed variations of this treatment on more than 20 books found in the General and Special Collections of the MIT Libraries. The group will present information about how the treatments have fared on the books over the past 2 years, including the benefits and limitations of the procedure. Often the damage occurs at the "joints" and "hinges," the flexible areas that allow the front and back covers to flex open and close. The repair uses methyl cellulose, wheat starch paste, various weights of Japanese tissues, and sometimes textile for badly damaged or heavy books. This treatment is delicate yet sturdy, and although originally developed for non-circulating special collections, recently it has also been implemented into circulating collections. With its versatility, noninvasiveness, aesthetic sensitivity, and time and material economy, this repair results in a custom-made, functional, and historically conscious treatment that serves well for both special- and general collections care.

JANA DAMBROGIO
Thomas F. Peterson Conservator
MIT Libraries, Wunsch Lab
Cambridge, MA
jld@mit.edu

AYAKO LETIZIA
Conservation Associate
MIT Libraries, Wunsch Lab
Cambridge, MA
ayako@mit.edu

MARY UTHUPPURU
Springleaf Press
Bloomington, IN
mary@springleafpress.com

BRIEN BEIDLER
Bloomington, IN
brienbeidler@gmail.com

KATE BEATTIE
MIT Libraries, Wunsch Lab
Cambridge, MA
knb@mit.edu

EMILY HISHTA COHEN
Paper Conservator
MIT Libraries, Wunsch Lab
Cambridge, MA
cohen.emily.h@gmail.com

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

HOLLY HERRO, SCOTT NOLLEY, WENDY COWAN, AND KRISTI WRIGHT

Oil on Paper: A Collaborative Conservation Challenge

ABSTRACT

The application of oil-based leather dressing, once considered a best practice in libraries, led to undesirable long-term consequences for bound materials. At the National Institutes of Health in the National Library of Medicine, many leather-bound volumes had multiple applications of a mixture of neat's-foot oil and lanolin dressings applied liberally. The oils not only absorbed into the leather bindings but also migrated onto the pastedowns, end sheets, gutters, and text blocks. The oiling process at the National Library of Medicine was documented by call number, year(s), number of applications, and dressing formula. While investigating treatment options, National Library of Medicine book conservator Holly Herro consulted paintings and objects conservator Scott Nolley for insight on viable options for the removal of oil from artifacts. An art-on-paper conservator, Wendy Cowan, joined the collaborative effort to develop a treatment protocol for the National Library of Medicine's oil-saturated collections. Together, they investigated the issue and devised an effective method for removal of this oil from the National Institutes of Health collection materials. The protocol involves washing with an alkaline solution, followed by alternating applications of petroleum ether and acetone applied either over suction or by immersion. Oil components are solubilized by the alternating polarities of the solvents and then removed from the paper using suction or immersion. After the oil is removed, the paper is washed again with alkaline water to remove any remaining water-soluble discoloration. This paper will explore further details of the treatment protocol, its development and applications, and the benefits of cross-disciplinary collaboration.

INTRODUCTION

The application of oil-based leather dressing resulted in condition problems for many library materials in the National Institutes of Health (NIH), National Library of Medicine (NLM), History of Medicine Division (HMD) collection. Problems include weakened binding structures; spue/bloom; and, most noticeably, oil-saturated paper. The oil is concentrated on the end sheets, pastedowns, and gutters, causing embrittlement and discoloration. Although the oil does not appear to be actively migrating further into the text blocks, the weakened, brittle, and discolored substrates are a concern for both the conservation and curatorial staff.

A NOTE ON TERMS AND PROCESSES

Oiling, *oiling-off*, and *dressing* are terms used by bookbinders to refer to the process of applying a mixture of fats, oils, waxes, and other substances to animal skin bindings. To maintain continuity in this paper, the term *dressing* will be used to reference the procedure and *leather* to generally reference animal skin bindings.[1] These dressings, which varied in composition, were believed to "prevent or retard deterioration, preserve, and, to a limited extent, restore flexibility to leather" (Roberts and Etherington 1982, 154). In some cases, potassium lactate was also applied as part of the dressing procedure. Leather dressing application was widespread among both individuals and institutions for decades. In many cases, the procedure provided an immediately satisfying tactile and visual improvement in the condition of the bindings, along with a sense of having "done something" for the books (National Park Service 1993), an effect that likely delayed cessation of the practice once evidence of dressing-related damages began to appear. This evidence did eventually result in the discontinuation of accepted use and the relegation of the practice to the category of damaging former treatments.

A BRIEF REVIEW OF THE HISTORY OF THE PRACTICE OF LEATHER DRESSING

Tanneries have long been adding fats during the manufacturing of leather, but the earliest use of dressing on leather bindings is not widely documented. One hypothesis, published by McCrady (1990) in the *Abbey Newsletter*, states the widespread use of leather dressing on other common leather materials, such as shoes, harnesses, saddles, and other tack led

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

to the eventual use on leather books. With the advent of the Industrial Revolution, there was an increase in indoor air pollution, and this, combined with the addition of sulfuric acid to the tanning and dyeing processes, led to increased leather deterioration commonly referred to as red rot. Atmospheric sources of sulfur dioxide were documented beginning as early as 1850 (Haines 1977, 59), and this led book owners to turn to the primary technique employed in protecting other leather products: the application of leather dressing (McCrady 1990). Leather dressing was undertaken both on bindings in pristine condition and, typically in conjunction with consolidation techniques, on bindings already affected by red rot.

The process of applying leather dressing and numerous bookbinding dressing formulas are well documented. Pamphlets, books, brochures, and videos are available with instruction on selecting and/or mixing and applying dressing to bound materials. Most dressing formulas contain oils, fats, and waxes in addition to various other additives. The most common component is lanolin, a translucent, yellowish-white wax extracted from raw wool. It is useful for its emulsifying properties, penetrating power, and shelf life. Neat's-foot oil, a pale yellow fatty oil made by boiling the feet (excluding hooves), skin, and shinbones from cattle, is a frequent companion to the lanolin. Either beeswax or a vegetable wax, slightly harder than lanolin, was sometimes added to boost the body of the dressing. Some of the most commonly referenced dressings also contain cedarwood oil as a thinner for control of consistency and primarily for its fungicidal effects (AIC Wiki 2009).

The earliest household leather dressing formula located by McCrady (1990) is a 1795 recipe intended for shoes and advertised for "making leather impervious by water." This and several other early recipes included common components of some of the later bookbinding dressings. However, it was petroleum jelly—a waxy hydrocarbon marketed under the then recently patented brand name Vaseline—that made an appearance by 1890 as one of the earliest recommended leather bookbinding dressings.

The Worcester County Law Library began using petroleum jelly on law books around 1910. In 1933, the U.S. Department of Agriculture (USDA) published a leaflet encouraging the use of leather dressings to "add many years to the service of a leather binding" through protecting the fibers and sealing them against atmospheric pollutants. The leaflet directs book owners to apply dressing to bindings when new and to repeat the process every year or two. The reasoning behind the repeat application was that lapses in dressing application would allow for more absorption of pollutants and ultimately resulted in decay that could not be repaired with further applications, although it could be slowed. The USDA leaflet encouraged both the use of a purified petroleum jelly and a 60:40 neat's-foot/lanolin mixture that was developed by the New York Public Library (Frey and Vetch 1933).

Two of the more widely referenced dressing formulas are the British Museum leather dressing and the New York Public Library formula described earlier. The British Museum leather dressing was primarily lanolin with the addition of cedar oil, beeswax, and a solvent—most commonly hexane. Some formulas, such as one from the Central Research Laboratory, were tailored to the fat content of the leather but commonly included a combination of lanolin, neat's-foot oil, and either TERIC N9 (a surfactant) or Shellsol T (a hydrocarbon solvent). Common materials found in other dressing recipes included sodium stearate, water, castor oil, and sperm oil. Often, leather dressings were preceded by the application of a 7% potassium lactate solution (Plenderleith 1946, 18-22). The USDA leaflet provided seven different choices for leather dressing ranging from off-the-shelf products to recipes for mixtures (Frey 1933). In a 1956 update, Rogers and Beebe (1956) added commercially available saddle soap to this list of options.

Plenderleith (1946) confirmed the USDA reasoning behind dressing leather, stating that the goal of the dressing was to provide "a lubricant for the fibrous tissue, preventing it from drying up and cracking." This was commonly referred to as "feeding" the skin. Both this and the 1933 USDA publication address red rot, but Plenderleith determined that the powdery substance was not a result of the leather "drying up" and states that neither the application of potassium lactate nor leather dressing prevents or treats red rot. He presents an examination of the sulfuric acid absorption process in leather and notes that degradation continues with or without the application of dressing. Despite this, Plenderleith encourages the use of dressing to combat wear and tear:

> When chemical deterioration has once set in, it cannot be cured or even satisfactorily arrested by belated treatment with lactate. In such cases the best course is to apply the British Museum Leather Dressing, which will soften the tissue and prevent the powdery surface from spreading. (Plenderleith 1946, 22)

Consolidation of red rot was initially attempted via the application of lacquers. First, the books were dressed, then a day or two later, a spray or brushed coat of cellulose nitrate-based coating would be applied. Although it was known that leather dressing would not consolidate the deteriorated leather, the dressing could not be applied over the impervious lacquer used for this purpose, so powdery books were rubbed as smooth as possible, dressed, and lacquered (Frey 1933, 6). The 1956 updated USDA publication concurred with Plenderleith's assessment of the reasoning behind dressing deteriorated leather (Rogers and Beebe 1956), and subsequently many other institutions followed suit. However, Plenderleith's aim in addressing red rot in 1946 did not have the intention of treating it but rather to encourage binders to use skins that passed the Printing Industries Research

Association (PIRA) test for leather. It was his claim that this leather contained a "protective ingredient" that would limit the degradation due to atmospheric sulfuric acid (Plenderleith 1946, 24). Dressing applications were encouraged as a means to replace absent oils or greases in the bindings whether or not the leather had passed the PIRA test.

Despite the prevalence of dressing leather, guidelines printed in leaflets on the subject varied greatly regarding application methods, frequency, formulas, and selection of materials. There was general agreement that leather deterioration happened due to acidity, but some speculated that it might also be affected by a lack of certain materials, be they nontans, salts, or grease. Most agreed that dressing leather did not stop deterioration. Only some advocated for the application of potassium lactate first, with a large range in recommended drying times. Dressing application methods ranged from "apply small quantities by hand using a cotton swab" (Rogers and Beebe 1956) to "the oil should be applied quite liberally with a paint brush" (Banks 1967). Recommendations regarding dressing books affected by red rot also varied. Some leaflets note that powdery leather absorbs more dressing, whereas others state that dressing these books is ineffective but "does no harm," and another recommended dressing "all leather books, even the powdery ones." Most institutional leaflets did provide some guidance regarding protecting the text block or taking care with nonleather portions of the volumes. As for frequency, some direct the user to repeat the process yearly, some every two to five years, and some only "if dry looking." As an additional measure, to encourage dressing absorption, books were sometimes placed in 100°F to 115°F locations for several hours (Frey and Vetch 1933).

One treatment procedure for dressing a leather volume is as follows (Plenderleith 1946, 20):

Scrub dirty binding with soap and water
Open book, allow to remain for a day standing on end to dry
Carefully sponge dry book with 7% Potassium Lactate solution
After 24 hours, rub a little of the British Museum Leather Dressing on the surface
After 2 days, polish binding and return book to shelf.

Environmental controls are emphasized in most of the leaflets as a preferred preservation method, with temperature and humidity as the focus. In 1975, the Library of Congress recommended set points of 60°F to 68°F and 55% to 65% RH, aiming to maintain a high enough humidity so that the leather would not dry out. References to nonleather skins are also present in the leaflets, but again, recommended actions vary. Some limit guidelines to restricting the use of potassium lactate on these skins. Others also restrict the use of dressing on them but encourage the use of soaps. On the conservative end, staff at the USDA in 1956 state that "valuable leather bindings that are not in frequent use may be wrapped in some well-washed fabric or stored in tight boxes." A chart of available leaflet comparisons is available in the *Abbey Newsletter* (McCrady 1981a, 25).

By the 1970s, dressing leather had become a standard institutional practice in many libraries. The mind-set by this time appeared to be focused on using the dressing as a cleaning mechanism rather than a preservation method. However, despite widespread implementation, the process was not always carried out by fully trained staff. At the Library of Congress, dressing was a component of the Phased Conservation program from 1971 to 1980. According to Waters (1998) at the time of his arrival to the Library of Congress in 1971, one staff member was assigned to dressing volumes, and this task was generally performed "without adequate supervision or adherence to treatment standards." Likewise, Etherington (1983) emphasizes that the person performing the dressing was often poorly paid or a volunteer and "invariably housed in the basement or attic or hidden somewhere in the stacks." Additionally in 1971, dressing was a regular part of collection maintenance at the Newberry Library, where the library's plan included "individual repair work as needed, proper storage, dusting and, in the case of leather bindings, periodic oiling" (Towner 1933, 155). In the latter case, the dressing was intended to lubricate the fiber bundles and thus reduce the need for dusting.

The practice of dressing leather continued to be widespread in institutions through the 1980s. For example, there are records of regular applications of dressing at the NLM during this time. The Pierpont Morgan Library completed a major leather dressing project in 1984. The Library of Congress was researching the effectiveness of different leather dressing formulas but routinely using the NYPL formula thickened with carnauba wax. However, by this point, anecdotal evidence alluding to potential problems had started to surface, and the benefits of the practice were under examination. It was also during this time that the application of hydroxypropylcellulose (Klucel G) as a consolidant prior to dressing was introduced by Anthony Cains (Evetts 1984). McCrady sums up decades of institutionalized leather dressing: "The dressing of leather bindings is a popular and well-established procedure, yet there is a fair amount of experimental evidence that it has little or no effect on leather's rate of deterioration. Whether the costs of a dressing program are justified by its benefits is a matter for each library to decide." (McCrady 1981b, 25).

Ultimately, most libraries discontinued their leather dressing programs, although the reasoning behind these conclusions was not purely a cost-benefit analysis but rather due to the combination of a lack of clear benefit and a growing body of evidence pointing to dressing-related damages.[2] Some of these damages were presumed to be the result of unsupervised application by untrained individuals as described earlier (McCrady 1990). Overzealous or cavalier application led to oil migrating into the text block, causing staining and embrittlement (Brewer 2006). Overdressed bindings were sometimes sticky or discolored due to the quantity of dressing applied (Hadgraft 1989). Spue appeared on many previously dressed leathers, most often those known to be treated with both a neat's-foot oil/lanolin dressing and potassium lactate (Gottlieb 1982; DePhillips and Mader 1997). In some cases, mold appeared (McCrady 2001). Spine and sewing damage resulted from the application of dressing to thin, poor-quality leather on many mass-produced bindings (Conn 2005). Metal furniture exhibited corrosion due to its proximity to oily leather (AIC Wiki 2011).

As documentation of damage increased and evidence for the benefits of leather dressing failed to surface, the application of leather dressing declined as an institutional practice. By the late 1990s, even those preservation publications that did provide instructions for the application of dressing typically did so with caveats (Heritage Collections Council 1998, 54). By 2000, the practice of using leather dressings on original bindings had declined noticeably (St. John 2000).

Current institutional policies trend toward minimal intervention for deteriorating leather. Ensuring adequate housing and polyester dust jackets for books displaying red rot are common recommendations for the general public (Library of Congress 2017). Leather dressing is no longer a widely practiced conservation treatment on original bindings, and when red rot consolidation efforts are undertaken in the conservation laboratory, they instead typically involve some combination of ethanol-based applications of hydroxypropylcellulose (Klucel-G); an acrylic polymer such as SC 6000; or a combination of the two, known as the CCAHA Red Rot Cocktail or Cellugel (Hain and Straw 2011). There are both ongoing and published studies evaluating the effectiveness of these and other materials for red rot consolidation. As is the case with many former treatments, however, the private collector continues to have access to nonconservation resources touting the wonders of leather dressing, including online video instruction for applying a variety of available off-the-shelf formulas.

NLM CASE STUDY

FORMER USE OF LEATHER DRESSING AT THE NLM

Leather dressing was routinely applied to bound materials at the NLM in the 1970s and 1980s. The formula used was a 60:40 mixture of neat's-foot oil and lanolin. Records indicate that most animal skin bindings were dressed twice: once in the 1970s and once in the 1980s. Dressing was applied by a full-time library professional who dedicated half of her time to conservation and preservation activities, but at the time, the NLM did not have a conservation laboratory. Dressing was applied primarily to leather but was also applied to parchment and vellum covers in some cases. Thorough dressing migration into the end sheets, pastedowns, and gutters is present in some bindings (fig. 1). Page edges are also sometimes affected, presumably as the result of liberal dressing application. Evidence of previous dressing migration can also be found on materials later rebound in buckram library bindings. It is unknown whether these volumes were dressed at the NLM or elsewhere, but based on other provenance, the former seems most likely. In addition to the migration of oil into the paper, spue was documented in sections of the collection.

PREVIOUS RESEARCH ON THE REMOVAL OF LEATHER DRESSING FROM PAPER

The search for an oil removal method was initially requested for aesthetic purposes by a curatorial staff member. Conservation staff assessed the situation, and although many of the affected pages are modern end sheets, others are historic and the presence of oil could pose a long-term structural problem. Verbal consultations with other conservators and a literature search revealed that similar oil migration is present at other institutions, and several studies exist on the removal of oil from paper. Some previous studies reduced the oil, although none fully removed all of the neat's-foot/lanolin dressing components from the substrate. The prior studies contain excellent information and should be considered by conservators approaching similar treatments, but early attempts by the NLM conservation staff to test oil removal using known methods were not successful in this situation.

As explained in the work of Stockman (2007), oils can be nondrying, semidrying, or drying. Higher numbers of double-bonded carbons correlate to a higher degree of drying. The number of double bonds can be determined by the amount of iodine that will react with the oil. The iodine number, in most instances, can be correlated to the color of the oil. A darker-colored oil generally has a higher iodine number and more double bonds and is more drying than a lighter-colored

Fig. 1. Example of an oil-saturated end sheet in the NLM collection. Photograph by Scott Nolley.

oil. One of Stockman's tests indicated that two or more solvents in succession applied via pipet over suction solubilized different components of a linseed oil stain, which has a high iodine number. Solvents applied were toluene, methanol, pyridine, tetrahydrofuran, and methyl ethyl ketone.

Lower iodine numbers/fewer double bonds typically result in oils that are easier to reduce. The leather dressing examined for the NLM study is a mixture of oil types with neat's-foot oil having an iodine number between 69 and 76 and lanolin having an iodine number between 15 and 49, thus putting the mixture between semidrying and nondrying (CAMEO 2016a, 2016b). Oils typically have both lipophilic and hydrophilic components. Neat's-foot oil is a mixture of various fatty acids that are approximately 67% oleic and 17% palmitic, with the remaining 16% consisting of other components. Lanolin is a mixture of high molecular weight alcohols and fatty acids.

Campbell (2009) individually evaluated the effectiveness of aqueous treatments, hexanes, isopropanol, acetone, and lipase for the removal of three different neat's-foot/lanolin-based dressing formulas from paper. The study focused on both historic and modern papers that underwent accelerated aging after the dressing was applied directly to the paper. Although several of the tests were partially effective at removing dressing components, none was fully effective at removing the waxy components present in some dressings. Campbell's study also examines the effects of the selected solvents on printing inks, which is imperative to consider if embarking on a dressing removal treatment that has affected media.

While investigating the potential treatment options, NLM book conservator Holly Herro consulted Scott Nolley, chief conservator at Fine Art Conservation of Virginia, based in Richmond. Given the prevalence of lacquers and other coatings on paintings, Herro thought that Nolley might have some insight into methods for removing the oil. Although Nolley did not have an immediate solution, he was intrigued by the problem of oil embedded in paper and requested a sample for testing.

DEVELOPMENT OF A TREATMENT PROTOCOL

A modern, but naturally aged, oil saturated end sheet from a 15th century book, *Practica, seu Lilium medicinae*, was selected from the NLM collection (Bernard 1496). The book had been rebound in the 1940s, and the blank, modern, unsympathetic end sheet was approved for testing, removed from the volume, and sent to Nolley for experimentation. The paper is 6 mils thick and laid. This sheet was divided into eight numbered strips to be used for testing (fig. 2).

Acting on the premise of the like-dissolves-like and using the steps described later, the following treatment protocol was explored for the NLM case study. The treatment protocol

Fig. 2. End sheet cut into test strips for experimentation. Photograph by Scott Nolley.

uses a similar concept to both the Stockman and Campbell studies for solubilizing the oil components but differs in that it incorporates the combined effect of pre- and postaqueous treatments with the effective use of alternating polarity solvents using suction or immersion.

The overall rationale for testing was to determine if some solvent systems used typically in paintings and objects conservation to affect oil residues could be used successfully to move oil out of paper. Nolley started testing solutions for oil mobilization by locally swabbing the samples and allowing the solution to wick into a thickness of cotton blotter situated below the sample (fig. 3). Unsightly tide lines appeared in the substrate, and for help resolving this, Nolley consulted local art-on-paper conservator Wendy Cowan of Richmond Conservators of Works on Paper. They concluded that while the swab application of a combination of polar and nonpolar solvents was moving oil laterally through the paper substrate, it was not being pulled out. For effective oil reduction, the samples either needed to be immersed in a solvent bath or the treatment performed using a suction device.

Based on Nolley's experience with semidrying and nondrying oils, and after considering the known properties of the 60:40 neat's-foot oil/lanolin combination, a range of options

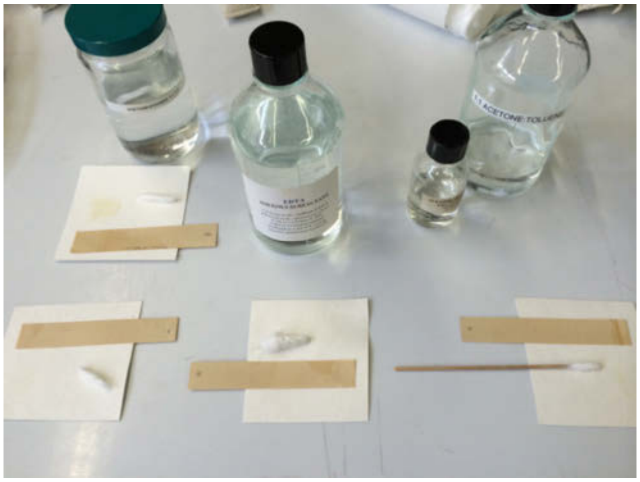


Fig. 3. Swab application of solvent. Photograph by Scott Nolley.

from immersion and swab treatments with aqueous and nonaqueous polar and nonpolar solvents, bleaching, and nonionic surfactants were tested. The degree of oil removal was qualitatively assessed using long-wave UV light. Residual oil fluoresces under UV light, indicating that removal is not complete (fig. 4).

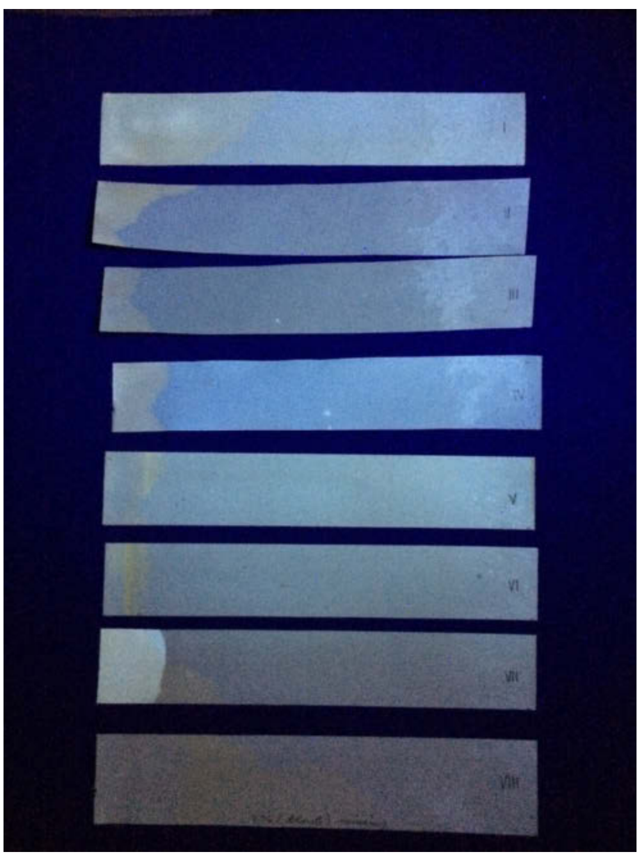


Fig. 4. Effectiveness of oil removal can be evaluated using long-wave UV light. Photograph by Scott Nolley.

In the first stage of testing, the following solvent combinations were tested on the numbered samples; sample I was the control in this experiment, and all ratios are volume to volume:

I. Control
II. Immersion in deionized water buffered to pH 9.0 with ammonium hydroxide
III. Immersion in 1:1 deionized water and ethanol buffered to pH 9.0 with ammonium hydroxide
IV. Immersion in 1:1 deionized water and ethanol buffered to pH 9.0 with ammonium hydroxide, then immersed in a 3% hydrogen peroxide and water solution followed by two baths with calcium carbonate
V. Swab application of 1:1 acetone:ethanol
VI. Swab application of 1:1 acetone:toluene
VII. Swab application of aqueous nonionic surfactant system with 2% ethylenediaminetetraacetic acid (EDTA)
VIII. Swab application of 20:20:40:20 mixture of acetone, diacetone alcohol, naphtha, and methanol (Acetone Mixture IV).

These initial results led to a second testing stage that involved dividing each strip in half and renumbering ii.a, ii.b, iii.a, iii.b, and so forth. The treatment protocols were reversed on one of these half-strips for each sample. Samples ii.b, iii.b, and iv.b, which had been washed in the first stage, were treated with solvents in this stage. Samples v.b, vi.b, vii.b, and viii.b, which were tested with solvents in the first stage, were immersed in the aqueous cleaning solutions in this stage (fig. 5).

The results in normal illumination indicated that the nonaqueous solvents—acetone and petroleum ether—were most effective in mobilizing oil, and thus these were the solvents chosen for samples ii.b through iv.b in the second stage of testing. Samples v.b through viii.b were immersed in a 1:1 deionized water and ethanol bath raised to pH 9.0 with ammonium hydroxide. The selected treatments for stage 2 were based on observations on the most effective methods in stage one (fig. 6).

The effectiveness of the combined treatment is evident in the comparison of samples ii.b and iii.b. Of these, iii.b exhibited a greater degree of oil reduction than ii.b. The difference in methodology for these two samples was the addition of ethanol to the initial bath for sample III. Samples v.b through viii.b, which were swabbed with solvents in stage one and immersed in stage two, did not display ideal results. Although the surfactant system applied in sample vii successfully removed the oil, the surfactant was not effectively removed from the paper. It is the combination of the initial washing treatment and the subsequent application of the alternating polarity solvents via either immersion or suction table treatment that is necessary to remove the tide lines and discoloration from the paper.

Fig. 5. Samples in normal light after first stage of testing. Photograph by Scott Nolley.

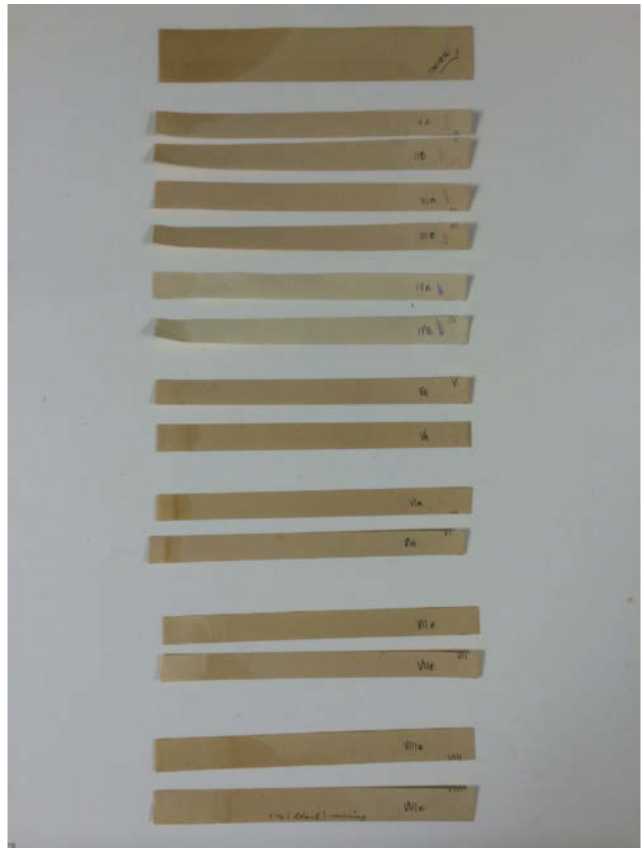


Fig. 6. Second stage of testing reversed the first-stage treatment protocol. Photograph by Scott Nolley.

The treatment protocol for the NLM case study was as follows. After spot-testing any media, prewash the affected page in a 1:1 solution of deionized water and ethanol buffered to pH 9.0 with ammonium hydroxide. In these tests, the samples were washed in three baths totaling one hour and air-dried. Applying solvents with a pipet over suction or using immersion, first use petroleum ether, a low-polarity solvent that solubilizes the lanolin. Then use acetone, a high-polarity solvent, to solubilize the neat's-foot oil. Continue alternating these solvents at a 1:1 ratio, changing the blotters regularly if using suction, until the oil is visibly reduced. To evaluate the oil removal treatment, periodically view the substrate using a long-wave UV light and look for any fluorescence of remaining oil. After the oil is reduced, wash the paper in a deionized water buffered to pH 9.0 with ammonium hydroxide.

TREATMENT REPLICATION

The NLM conservators proceeded to replicate this treatment process on several additional oil-saturated leaves. The first page tested was the corresponding end sheet to the one used for the development of the treatment protocol. This treatment was performed as an in situ spot treatment on the suction table. The oil was successfully reduced in both visible and UV light after approximately nine alternating applications of the solvents (fig. 7).

The second sample chosen was also a nonhistoric oil-saturated end sheet. The end sheet was removed for testing. It was 9-mil-thick laid paper that is heavily sized as determined by a water droplet test. After more than 40 applications of each solvent, some of the oil appeared to be reduced in visible light, but staining continued to be present in visible light and substantial fluorescence remained under UV light. Most of the observed oil reduction occurred in the first nine suction table solvent applications. A second sample from this leaf was immersed in alternating baths of petroleum ether and acetone with similar results. The authors hypothesize that the remaining oil in this substrate is attributed to the sizing and fillers in the paper, which interfere with the oil reduction and possibly contribute to the continued fluorescence under UV.

The third leather dressing-saturated paper tested was the first historic sample selected for treatment—a detached, blank end sheet from a late 18th century book. The end sheet was treated on the suction table using the developed treatment protocol. The paper was 7 mils thick, wove, and lightly sized as determined by a water droplet test. Nine applications

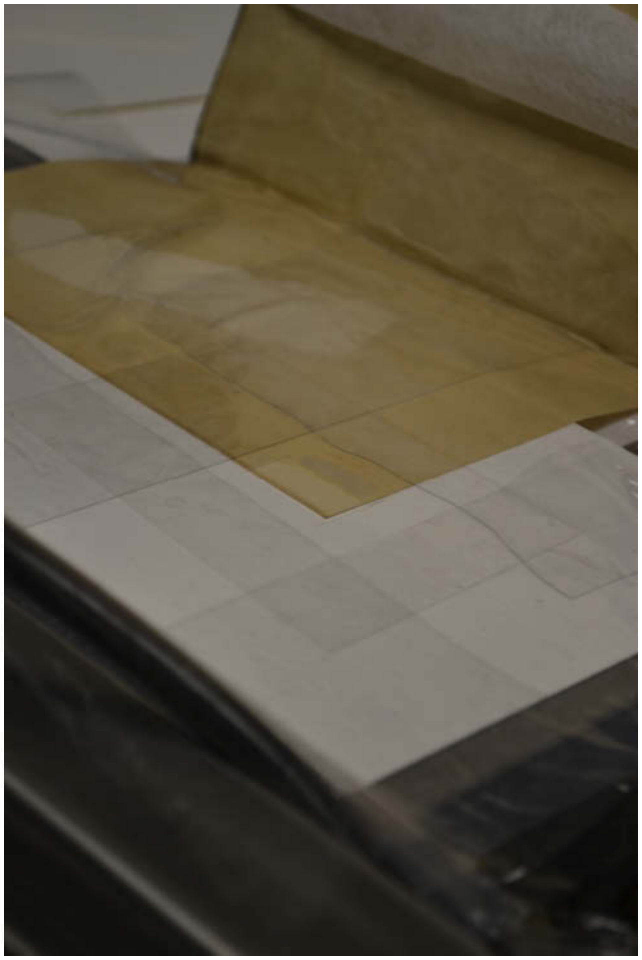


Fig. 7. Suction table application of solvents is a possibility for in situ treatment. Photograph by NLM staff.

Fig. 8. During-treatment photograph of historic end sheet with oil partially removed. Photograph by NLM staff.

of each solvent using suction reduced the oil in both visible light and UV light (fig. 8).

During the course of this study, a manuscript saturated with motor oil was brought to the NLM conservation laboratory for treatment. The oil had considerably darkened the 4-mil wove, well-sized substrate. The paper was brittle and fragmenting throughout. Although motor oil is a petroleum-based nondrying oil, the authors chose to test the treatment protocol on an already separated ¼ in. blank fragment. The oil was successfully reduced using nine alternating applications of each solvent using suction.

OBSERVATIONS AND RECOMMENDATIONS FOR FURTHER STUDY

The end sheets tested to date have not contained media and, as with any solvent treatment, spot-testing must always be undertaken when treating any object. The pre- and post-treatment baths prevent tide lines and remove any residual water-soluble discoloration, respectively. This combination of prewashing the samples to prevent tide lines and mobilizing the oil-based leather dressing using alternating polar and nonpolar solvents emerged as the most effective treatment protocol. Although the treatment methodology discussed here is effective at solubilizing the specific 60:40 neat's-foot oil/lanolin dressing mixture present on the NLM materials, further research needs to be done on reducing oil migration from other leather dressing formulas.

Additional testing of this treatment protocol on nondressing oils, such as motor oil, could also be beneficial. It is the authors' observation that it is necessary to consider some aspects of the composition of the paper when considering this treatment option. With the known dressing mixtures, investigation into how fillers, sizing, and coatings found in substrates affect the results and aging studies to determine the long-term effects of the treatment on the substrate is necessary. For all of the aforementioned research needs, quantitative analysis to further examine the results will be considered for future testing.

This cross-disciplinary collaboration was a great experience for the project team that resulted in a new treatment protocol to consider for removing the specific leather dressing found on the NLM collection. Of course, no treatment can be used universally due to the many factors to consider for each collection item. This project gave the NLM book and manuscript conservators the opportunity to explore treatment options from conservators in other disciplines and resulted in a successful method for reducing the oil in text blocks damaged from leather dressing application. The project team hopes that this case study will encourage other conservators to seek the valuable advice and guidance from colleagues both within and outside their respective disciplines when faced with a difficult treatment.

ACKNOWLEDGMENTS

This project would not have been possible without the support of the NIH, NLM, and HMD, particularly Chief Jeffrey S. Reznick, Ph.D.; Deputy Chief Kenneth M. Koyle, MA, M.Ed.; and head of the Rare Books and Early Manuscripts Division, Stephen J. Greenberg, MSLS, PhD. The authors would also like to acknowledge the following conservation colleagues for their contributions to this topic: Sylvia Albro, senior conservator, Library of Congress; Thomas Albro II, former head of book conservation, Library of Congress; Brenna Campbell, book conservator, Princeton University Libraries; William Minter, book conservator, Pennsylvania State University Libraries; Denise Stockman, conservator for paper, New York Public Library; and Katharine Wagner, book conservator, Smithsonian Libraries.

NOTES

1. It should, however, be noted that dressings were sometimes applied indiscriminately to tanned, tawed, and parchment skins. In the authors' observation, in some instances dressing was even applied to cloth or paper bindings, presumably due to misidentification.

2. Oil-damaged paper is not always a result of the application of leather dressing. Some tracing papers were intentionally impregnated with oils to render them transparent (Bachmann 1983). Oily stains in paper can have many sources, such as cooking oil or motor oil. On bound materials, leather burn, particularly common on turn-ins, is not a result of dressing application but rather oils added during the tanning process (Conroy 1991). Although leather burn could presumably be exacerbated by leather dressing, many procedures did not recommend the application of dressing to turn-ins.

REFERENCES

AIC Wiki. 2009. Parchment (PCC). http://www.conservation-wiki.com/wiki/Parchment_(PCC).

AIC Wiki. 2011. Ethnographic objects. http://www.conservation-wiki.com/wiki/Ethnographic_Objects.

Bachmann, K. 1983. The treatment of transparent papers: A review. *AIC Book and Paper Group Annual* 2: 3-13. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v02/bp02-02.html.

Banks, P. N. (1965) 1967. *Treating leather bookbindings*. Reprint, Chicago, IL: Newberry Library.

Bernard, G. 1496. *Practica, seu, Lilium medicinae : de ingeniis curandorum morborum : de regimine acutarum aegritudinum : de prognosticis*. Venice, Joannes and Gregorius de Gregoriis, de Forlivio.

Brewer, T. 2006. SC6000 and other surface coatings for leather: Composition and effectiveness. *Bonefolder* 2 (2): 33-35. http://anet.ua.ac.be/desktop/ehc/static/ebooks/EHC_718969_vol1_vol2.pdf.

Campbell, B. 2009. The removal of leather dressing from paper. *AIC Book and Paper Group Annual* 23: 125-131. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v28/bp28-22.pdf.

Conn, D. 2005. Molded paper spine. *Bonefolder* 2 (1): 25-28. http://www.arts.ucsb.edu/faculty/reese/classes/artistsbooks/BonefolderVol2No1.pdf.

Conroy, T. 1991. Informal observations on "leather-burn", acidity, and leather lubricants. *AIC Book and Paper Group Annual* 10: 43-48. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v10/bp10-05.html.

DePhillips, H. A. Jr., and M. L. Mader. 1997. Identification of spue on leather books at Trinity College, Hartford. *Abbey Newsletter* 21 (2). http://cool.conservation-us.org/byorg/abbey/an/an21/an21-2/an21-210.html.

Etherington, D. 1983. Conservator and librarian. *AIC Book and Paper Group Annual* 2: 50-61. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v02/bp02-06.html.

Evetts, D. 1984. Treating 5000 books at the Pierpont Morgan Library. *AIC Book and Paper Group Annual* 3: 60-64. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v03/bp03-06.html .

Frey, R. W., and F. P. Vetch. 1933. Preservation of leather bookbindings. U.S. Department of Agriculture: technical leaflet 69.

Gottlieb, J. S. 1982. A note on identifying bloom on leather bindings. *Journal of the American Institute for Conservation* 22 (1): 37-40. http://dx.doi.org/10.1179/019713682806028469.

Hadgraft, N. 1989. The Parker Library Conservation Project, 1983-1989. *Library Conservation News* 24: 4-7.

Hain Teper, J., and M. Straw. 2011. A survey of current leather conservation practices. *AIC Book and Paper Group Annual* 30: 131-151. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v30/bp30-19.pdf.

Haines, B. M. 1977. Deterioration in leather bookbinding—Our present state of knowledge. *British Library Journal* 3 (1): 59-70. http://www.bl.uk/eblj/1977articles/pdf/article9.pdf.

Heritage Collections Council. 1998. Books. In *reCollections: Caring for collections across Australia*, *caring for cultural material 1*. Canberra, Australia: Heritage Collections Council. 30-66.

https://aiccm.org.au/sites/default/files/docs/reCollections/1_caring_for_cultural_material_1.pdf.

Lanolin. 2016a. CAMEO (Conservation and Art Materials Encyclopedia Online). Museum of Fine Arts, Boston. http://cameo.mfa.org/wiki/Lanolin.

Library of Congress. 2017. Should I oil my leather books? http://www.loc.gov/preservation/about/faqs/books.html#leath.

McCrady, E. 1981a. Dressing leaflets compared. *Abbey Newsletter* 5 (2). http://cool.conservation-us.org/byorg/abbey/an/an05/an05-2/an05-207.html

McCrady, E. 1981b. Research on the dressing and preservation of leather. *Abbey Newsletter* 5 (2). http://cool.conservation-us.org/byorg/abbey/an/an05/an05-2/an05-206.html.

McCrady, E. 1990. How leather dressing may have originated. *Abbey Newsletter* 14 (1). http://cool.conservation-us.org/byorg/abbey/an/an14/an14-1/an14-121.html.

McCrady, E. 2001. The mold conference in Munich: A report. *Abbey Newsletter* 25 (2). http://cool.conservation-us.org/byorg/abbey/an/an25/an25-2/an25-202.html.

Neats-foot oil. 2016b. CAMEO (Conservation and Art Materials Encyclopedia Online). Museum of Fine Arts, Boston. http://cameo.mfa.org/wiki/Neats-foot_oil.

National Park Service. 1993. Leather dressing: To dress or not to dress. *Conserve O Gram* 9 (1). https://www.nps.gov/Museum/publications/conserveogram/09-01.pdf.

Plenderleith, H. J. 1946. *The preservation of leather bookbindings.* London, UK: British Museum.

Roberts, M. E., and D. Etherington. 1982. *Bookbinding and the conservation of books: A dictionary of descriptive terminology*. Washington, DC: Library of Congress.

Rogers, J. S., and C. W. Beebe. 1956. Leather bookbindings: How to preserve them. U.S. Department of Agriculture: technical leaflet 398.

St. John, K. 2000. Survey of current methods and materials used for the conservation of leather bookbindings. *AIC Book and Paper Group Annual* 19: 131-142. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v19/bp19-32.html.

Stockman, D. 2007. Treatment options for oil stains on paper. *AIC Book and Paper Group Annual* 26 (115): 1-12. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v26/bp26-22.pdf.

Towner, L. W. 1993. A plan for the Newberry Library. In *Past imperfect: Essays on history, libraries, and the humanities*, eds. R. W. Karrow Jr. and A. F. Young. Chicago, IL: University of Chicago Press. 148-169.

Waters, P. 1998. Phased conservation. *AIC Book and Paper Group Annual* 17: 113-122. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v17/bp17-17.html.

HOLLY HERRO, MLIS
Senior Conservator
National Institutes of Health
National Library of Medicine
History of Medicine Division
Bethesda, MD
herroh@mail.nlm.nih.gov

SCOTT NOLLEY, MA, CAS
Chief Conservator
Fine Art Conservation of Virginia
Richmond, VA
facofva@aol.com

WENDY COWAN, MA
Conservator of Works of Art on Paper
Co-owner of Richmond Conservators of Works on Paper
Richmond, VA
wendy.cowan@verizon.net

KRISTI WRIGHT, MLIS
Contract Book and Paper Conservator
National Institutes of Health
National Library of Medicine
History of Medicine Division
Bethesda, MD
kristi.wright@nih.gov

KATHY LECHUGA

Treatment 305: A Love Story

ABSTRACT

Treatment 305 was developed at Princeton University Libraries by conservators Brian Baird and Mick Letourneaux. A paper detailing this binding structure was published in volume 13 of the Book and Paper Group Annual in 1994, entitled "Treatment 305: A Collections Conservation Approach to Rebinding." Essentially, a tight joint binding with a natural hollow and minimal spine linings was developed that incorporated aspects of 18th and 19th century bindings without any of their inherent weaknesses. The Treatment 305 structure provides an incredibly flexible and durable binding that opens very flat and places minimal strains on the book during use. Given the nature of the Indiana Historical Society's collection, Treatment 305 seemed like a logical solution to the dilemma of rebinding damaged late 18th to mid-19th century books, especially if a few adjustments could be made to tailor the structure, adhesives, and covering materials to a more special collections approach to rebinding.

INTRODUCTION

The Indiana Historical Society (IHS) library's collection policy states that it "collects all subjects and formats of research material, both primary and secondary, dealing with pre-territorial and territorial history, and the history of Indiana through the twenty-first century." The collection spans the period from approximately the late 16th century to the present day and includes many different paper-based formats, such as books, diaries, maps, manuscripts, prints, photographs, and architectural drawings. Simply due to the focus of IHS's collection, a substantial portion of printed books date from the late 18th through the mid-19th centuries. Many of these books exhibit typical damage, such as detached boards and split spines; however, there are a fair amount whose bindings are either nonexistent or so degraded that they need to be rebound. Many of the books without bindings have also sustained significant water damage or are heavily discolored and stained, which in some cases has warranted full treatments. Full treatments include washing, sometimes resizing, extensive guarding and mending, and ultimately rebinding in an appropriate structure taking period aesthetics into account.

IHS's collection is frequently used by the general public, by staff conducting research for publications, marketing, or upcoming exhibits, and by the preservation imaging department that creates various digital content for the IHS website. Materials need to be stable enough to withstand this type of handling and use, especially in the case of books, as bindings that are too tight can make digitization and their use difficult if not impossible. The manner in which the collections are used and the current increase in institutional exhibition of original material would best be served by bindings with good mobility and durability.

Recreating historical book structures is not without its complications, and there has been much discussion over the years of the pros and cons of replicating historical structures versus improving on them by creating "conservation bindings" (Brown and Ogden, 1998; Frost 1982; Haqqi 2016; Tribolet 1953). A conservator's reflex reaction is to do no harm and improve upon the original structure. It broke in the first place, so why should a faulty binding be recreated that could perpetuate damage? Preserving as much of the original object and its context as possible, even though it might require rebinding, has always been a priority; however, all original binding elements do not always need to be recreated. For example, a single-hold link stitch pattern can be used when resewing books that were previously bound around sunken cords rather than recreating the original sewing structure. The link stitch is a strong, flexible sewing and fills in gaps left behind by sawn-in cords. When appropriate, original sewing structures are recreated in an effort to preserve the history of how that unique book was put together. Reincorporation of original binding remnants with recreated sewing achieves an overall aesthetic reminiscent of the book's historical context. Hopefully, this approach to rebinding can provide the user with a fuller experience when handling the book, if even only on a subconscious level. In addition, information about the structure and binding styles of a given time period

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

can be better preserved for scholars interested more in the materiality of the book rather than its contents.

An important aspect of "conservation binding" is the creation of a structure that subjects a book to minimal risks for the rest of its usable life. The new binding should be constructed of good-quality materials that will age well and not adversely affect the original binding components, and will not deteriorate in the same way as historical binding materials; red rotted leather comes immediately to mind. It is a difficult balance: do you replicate a historical structure with all of its inherent vices and flaws, or do you improve upon it and use materials or structures that are not completely "historically traditional" but could improve the life of the object? Conservators wrestle with this question everywhere, and the answer will vary among objects as well as institutions. The ultimate goal when rebinding books in the IHS's collection is to improve their mobility so that they will essentially preserve themselves during use. However, a secondary goal is to create an object that is aesthetically harmonious with its time period even if there is not much left of the original binding. For instance, a modern case binding on a book from the 18th century would appear out of place, so a new structure more appropriate to its original publication date would be constructed instead. This is where Treatment 305 is useful. It bridges the divides between good mobility, durability, and aesthetics, which can be endlessly customized to place the book within its proper historical context all while using conservationally sound materials.

TREATMENT 305

In Baird and Letourneaux's original article detailing the Treatment 305 procedure, the authors specifically discuss the inherent problems associated with 18th and 19th century bindings, such as thinly pared leather joints that split, red rotted leather, and spines that are too stiff and impede mobility. They go on to characterize books from this period as having weak, broken bindings but strong text blocks printed on good-quality paper. This has certainly been the case with the majority of damaged 18th and 19th century books in IHS's collection that have come through the conservation lab. Baird and Letourneaux developed a tight joint, hollow back binding structure that is "congruous" with binding structures from this period without the inherent weaknesses (Baird and Letourneaux 1994). The resulting binding is extremely flexible and very durable, and it can be easily modified by using different sewing supports or covering materials, as will be demonstrated by the following treatment case studies.

SEWING

In the original Treatment 305 article, the authors preferred resewing text blocks using a two-hole link stitch pattern sewn around cloth tapes, which were chosen due to their durability and flexibility. They mention that other sewing structures can be used depending on the original sewing of the book, its value, and the choice of covering material. New double-folio endpapers were always added to a text block even if it would not be completely resewn. These would be attached using the same two-hole link stitch pattern sewn around tapes that had been adhered across the width of the spine.

SPINE LINING

The spine is rounded and backed as appropriate to the book, lined with a kozo fiber paper reversibility layer, then lined with an overhanging crash lining using polyvinyl acetate (PVAC). False endbands are added at this point if desired. Baird and Letourneaux state that usually a third lining is not necessary except in rare cases when it seems that the text block requires additional support. The minimal spine linings are what create the flexible mobility and allow the text block to lie nearly flat during use.

BOARD ATTACHMENT

The board attachment is essentially that of a tight joint binding, but the boards are not laced in; rather, the sewing supports and overhanging lining are inlaid into the tops of the boards. This type of text-to-board attachment creates a sturdy joint area that can easily flex repeatedly but is not as prone to splitting as thinly pared leather joints.

COVERING

A variety of covering materials can be used, providing myriad options when reproducing the aesthetics of historical bindings. The authors most often used cotton-linen blend materials because they are flexible, durable, and easily colored. Baird and Letourneaux even constructed molded spines using linen book cloth to accommodate original raised bands on the books that were not resewn. Another key aspect of this binding is that there is no paper spine inlay in the covering material. This allows for greater flexibility during use but also, more importantly, distributes the forces of opening across a greater area and does not concentrate them at the top of the shoulder and joints, which can lead to stress points that will eventually break.

The authors originally proposed this treatment as a bridge between special and general collection treatments for medium rare items that tend to be a large part of institutional book collections. After constructing a model and observing the benefits of this structure and the ease with which it could be made, it seemed completely appropriate for use on special collections materials and worth exploring further to determine if different materials and adhesives could be used in its construction, as the authors suggested.

TREATMENT CASE STUDIES

CASE STUDY 1

This item consisted of two groupings of pamphlets detailing early laws and acts of the Indiana Territory before it was established as a state in 1816. The text block was composed of handmade paper sections, with relief printed text and manuscript annotations written throughout the book in a variety of inks. These two groupings, or volumes, were different sizes and bound together using an abbreviated sewing pattern around two sunken support cords. There were remnants of original red and white striped false endbands adhered to the text block. These endbands were constructed by wrapping a piece of printed striped cotton cloth around a cord core.

When this book arrived in the lab, the only remaining original binding elements were the false endbands , a fragmented spine lining, and some remnants of the original sewing thread scattered throughout the sections (fig. 1). The text block was split in half at the point between the *Acts* and *Laws* volumes, essentially at the point where the pamphlet leaves changed size (fig. 2). The paper was significantly darkened and yellowed with signs of previous water damage in the form of tide lines and stains throughout. In addition, there were several tears throughout the text block and many detached leaves at the front and back sections. The paper from the 1792 *Acts* volume was also very limp and soft, with splits beginning to form in some areas.

After discussions with the curator, it was decided to separate this book into two volumes and rebind each one separately. Both treatments were similar, and both books were rebound using the Treatment 305 structure with matching covering materials. The only different treatment procedure was that the 1792 volume was resized and the 1802 volume was not, as the paper was much sturdier and in better condition overall. Since both treatments were so similar, only the treatment of *Acts Published by the Governor and Judges of the Territory* . . . (1792) will be described in the following. The decision to use the Treatment 305 structure was made after handling the fragile paper and having discussions with the curator on the importance of these books to the collection. He anticipated that the volumes could be frequently used, so a flexible binding that would not strain the text block and would hold up well over time was required. Given the books' publication period, Treatment 305 facilitated the creation of historically sympathetic bindings with more robust materials than would have been used traditionally. Other structures, such as French groove case bindings, would have looked too modern even if they allowed the book to function well. Non-adhesive paper case bindings were considered due to their flat opening but would not have been aesthetically appropriate for these books. As such, they would have appeared as more of an enclosure and would not have been in line with the curator's goals. This treatment was the first application of Treatment 305 to a collection item, and therefore Baird and Letourneaux's original procedures were followed closely before making any modifications.

Fig. 1. *Acts Published by the Governor and Judges of the Territory of the United States, North-West of the River Ohio* . . . (1792). Before treatment. The only remaining original binding elements were fragments of the false endbands, spine lining, and some remnants of sewing thread (not visible).

Fig. 2. *Acts Published by the Governor and Judges of the Territory of the United States, North-West of the River Ohio* . . . (1792). Before treatment. The text block had split at the point where the two volumes were joined together. The 1802 volume was smaller in size and could have caused structural issues if rebound in the original manner.

TREATMENT PROCEDURE

1. The spine was cleaned with a 4% (w/v) methyl cellulose poultice to remove the original broken spine linings and adhesive residues. The text block was disbound entirely and then collated into two-folio sections.
2. The text block was dry-cleaned with vulcanized rubber sponges and vinyl erasers. Pages were numbered in the upper foredge corners lightly in pencil to facilitate tracking during the treatment process (these marks were erased after the text block was resewn).

3. After testing of the various inks found throughout the text block, the sections were washed in baths of filtered water until clean. The leaves were alkalized in the final bath using a calcium hydroxide solution at pH 8.0. The text block sections were air-dried between Reemay on a drying rack to preserve as much of the original type impression and texture of the paper as possible.
4. Due to the limp and soft nature of the text block paper, resizing was necessary to strengthen the pages before rebinding. The leaves were resized in a bath of 0.5% (w/v) warm gelatin solution in filtered water. The sections were air-dried again between Reemay on a drying rack.
5. Once dry, the leaves were removed from the rack, collated, and placed between boards under light weight to compress the text block for two weeks.
6. The text block was guarded and mended, and losses were filled using thin, Barrett kozo fiber paper and Zen Shofu precipitated wheat starch paste. Kizukishi kozo fiber paper was used in several places where heavier fills were required.
7. Double-folio endpapers were constructed from Nideggen paper toned with Golden acrylics to closely match the color of the text block paper.
8. The text block was resewn using an all-along, two-hole link stitch pattern around three ¼ in. wide cotton twill tape supports (fig. 3) using a lightly waxed linen thread. Most of the section folds were heavily damaged, so most of the new holes were punched in the guard paper and not through the original text block paper.
9. The spine was consolidated with wheat starch paste, rounded and backed, and then lined with a reversibility layer made from Kizukishi kozo fiber paper.
10. New endbands were constructed using red and beige printed cotton cloth wrapped around a linen cord core stiffened with wheat starch paste. The endbands were then adhered over the reversibility layer with paste.
11. The final spine lining made of unlined linen cloth cut wider than the text block was applied with wheat starch paste instead of PVA.
12. New boards were constructed from two layers of four-ply museum mat board to accommodate the thickness of the shoulders and attached to the text block using the Treatment 305 structure by inlaying the overhanging linen lining and tapes into the tops of the boards.
13. The book was covered in a quarter style using Cotlin book cloth on the spine and Ruscombe Mill blue handmade paper on the boards. A laser-printed paper label was generated, coated with matte spray fixative, and adhered to the spine. The new binding elements and pastedowns were adhered with a 1:1 mix of Jade 403 PVA and 4% methyl cellulose (figs. 4, 5).

CASE STUDY 2

This book was another early Indiana government publication detailing the procedure of incorporating Indianapolis into Marion County and had clearly endured strange rebinding efforts over the years. The current binding was constructed from red leather with a gold title stamped on the front cover. The boards were made of heavy cardstock with blue machine-made paper pastedowns and were placed around the original, much older binding remnants. The original binding was a quarter-style brown leather and yellow paper tight joint structure with evidence of two support cords adhered under the pastedowns. The front yellow cover paper was printed with the title and publishing information, and there was a separate piece of paper with a large letter "A" written on it adhered to the outside of the original back board. This book

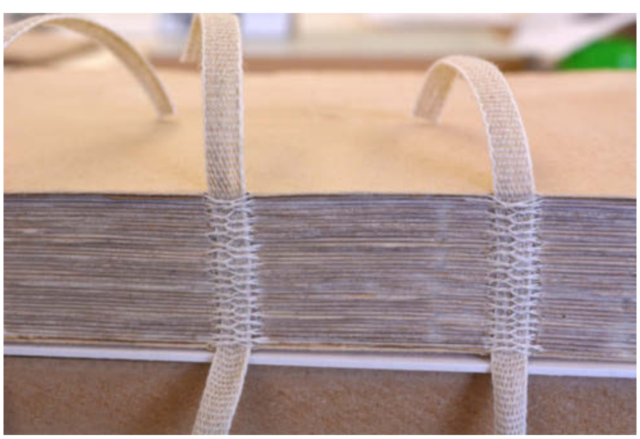


Fig. 3. *Acts Published by the Governor and Judges of the Territory of the United States, North-West of the River Ohio . . .* (1792). During treatment. The text block was resewn using an all-along two-hole link stitch pattern around cloth tapes.

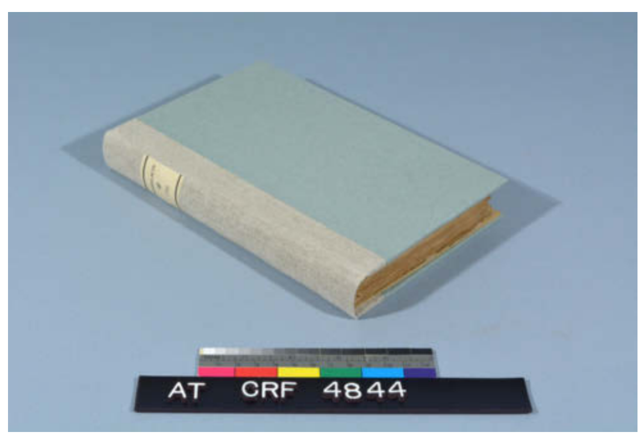


Fig. 4. *Acts Published by the Governor and Judges of the Territory of the United States, North-West of the River Ohio . . .* (1792). After treatment. Cotlin book cloth was used on the spine and Ruscombe Mill handmade paper on the boards to mimic the aesthetic of early publishers' boarded bindings from the late 18th century.

Fig. 5. *Acts Published by the Governor and Judges of the Territory of the United States, North-West of the River Ohio . . .* (1792). After treatment. The book opens and functions well and does not strain the pages during use.

Fig. 7. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). Before treatment. Red staining as a result of the red leather dye bleeding into the paper during previous water damage.

essentially had a binding that consisted of double boards at the front and back that were not laminated together. Only the original boards were attached to the text block by wide pieces of gray cloth tape. The text block was composed of two-folio sections sewn in an abbreviated sewing pattern around two sunken support cords.

Worse than the strange multilayered binding was the fact that this item had sustained heavy water damage, causing all of the boards to warp and covering materials and original pastedowns to delaminate (fig. 6). The red leather dye was also apparently water sensitive and had heavily stained several pages mostly at the front and back of the text block (fig. 7). The red leather was completely delaminated from the front and back boards, which were severely warped and brittle with large edge losses. The original binding elements were also heavily degraded, and the leather strips on the boards had blackened and become extremely brittle as a result of the water damage. The yellow printed paper covering material was heavily fragmented and cracked throughout with large areas partially delaminated from the original boards (fig. 8).

After extensive examination and discussions with the curator, it was decided to revert this book back to its quarter-style binding. There was some discussion of simply rebinding it in a paper case, but since so much of the original covering material remained and it contained information pertaining to the volume, it seemed more appropriate to reincorporate these materials into a usable structure. The red leather binding was obviously more modern and was so heavily degraded that it was unusable. In fact, most of the original binding elements could not be reused due to the significant level of damage they sustained. In addition to the text block and original pastedowns,

Fig. 6. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). Before treatment. The book was bound in a multi-layer binding and had sustained heavy water damage.

Fig. 8. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). Before treatment. The original binding elements with blackened spine leather and severely cracked and delaminated yellow printed paper covering material.

only the printed yellow paper covering material was salvageable and reincorporated into the new structure. It seemed as though Treatment 305 would again be appropriate since the resulting binding would be very flexible and would allow for easy incorporation of the original paper covering material. Due to the use of more original materials in the new binding, some different treatment procedures and materials were used than those described in Baird and Letourneaux's original article.

TREATMENT PROCEDURE

1. The text block was disbound entirely and the surface cleaned with vulcanized rubber sponges.
2. After testing the ink and pencil annotations for water sensitivity, the sections were washed in baths of filtered water and then alkalized in the final bath using a calcium hydroxide solution at pH 8.0. The leaves were air-dried on a drying rack between Reemay.
3. The bath failed to remove an adequate amount of red staining from the first three and last three sections, so they were subsequently blotter washed, which did pull out quite a bit more red colorant from the paper. The leaves were air-dried again on the drying rack between Reemay.
4. Damaged sections were guarded with Kizukishi kozo fiber paper, and tears were mended with Tengucho thin kozo fiber paper and Zen Shofu precipitated wheat starch paste.
5. The original pastedowns were composed of two layers of paper laminated together with a thick layer of animal glue. These were separated and cleaned in the bath and then hinged onto the first and last sections of the text block with Kizukishi paper strips.
6. The text block was resewn using lightly waxed linen thread in an all-along single-hole link stitch pattern, reusing the original sewing holes.
7. The spine was consolidated with wheat starch paste, rounded and backed, and then lined with a reversibility layer of Sekishu natural kozo fiber paper, followed by an overhanging linen lining.
8. The original yellow printed paper covering material was severely shattered and torn. The paper was lifted off of the original boards with filtered water and the aid of a polyester film support. The leaves were then blotter washed, which removed a significant portion of the red staining from the paper without compromising the cracked areas and small fragments (fig. 9).
9. The yellow covering material was then lined with wheat starch paste and thin Yame Kozo Hadaura paper, a dyed kozo fiber paper available from Talas, that was additionally toned with Golden acrylics before lining to better match the color of the original papers. The lined covering material was dried between blotters and boards.

Fig. 9. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). During treatment. The fragmented original covering material after blotter washing.

10. New boards were constructed by laminating two pieces of four-ply colored museum mat board with full thickness wheat starch paste as in the previous treatment.
11. The book was rebound using the Treatment 305 structure using only wheat starch paste as the adhesive. The text block was fairly thin, so sewing supports were not needed for reinforcement and only the overhanging linen lining was inlaid on top of the boards to create the text-to-board attachment.
12. A new spine piece was constructed by toning a strip of linen and kozo fiber paper laminate with Golden acrylics. After the material dried, SC6000 was applied and buffed with a soft cloth to produce a slight sheen to mimic the look of leather. The new spine piece was adhered to the new boards with paste.
13. The lined original printed covering material was adhered on top of the boards with wheat starch paste and dried under heavy weight (figs. 10, 11).
14. The original pastedowns were adhered to the inside of the boards with wheat starch paste in a two-step process to

Fig. 10. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). After treatment. Front overall with a new spine piece and the original covering material incorporated into the new binding.

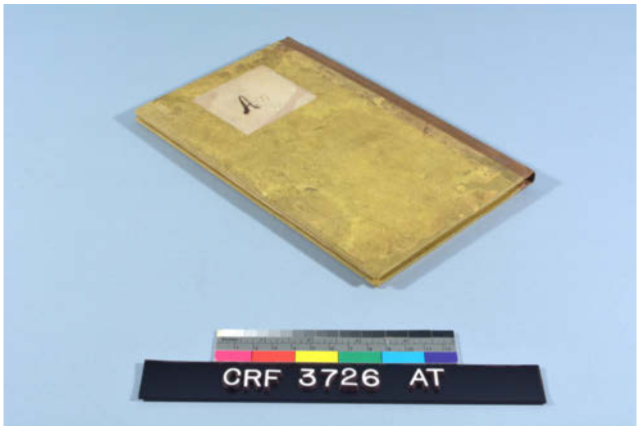


Fig. 11. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). After treatment. Back overall.

prevent the board from winging out from the text block.[1] After the first pastedowns were adhered and mostly dried, the second leaves were applied and then dried with fences between blotters and boards under heavy weight. The resulting binding functioned well with boards that laid flat (figs. 12, 13).

CASE STUDY 3

This book is part of a four-volume set detailing surgical techniques of the late 18th century, written by Benjamin Bell, a member of the Royal Colleges of Surgeons of Ireland and Edinburgh, one of the surgeons to the Royal Infirmary and fellow of the Royal Society of Edinburgh. This volume belonged to William Guthrie of Monticello, Indiana, a doctor practicing in the area in the mid-1800s. The only remnant of the original binding was a heavily fragmented brown leather spine piece that was gold tooled with three lines. There also remained about half of a red leather gold-tooled spine label

Fig. 12. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). After treatment. First page with red staining minimized.

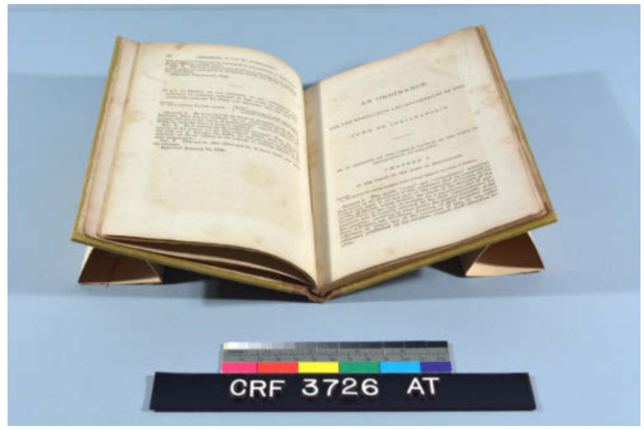


Fig. 13. *An Act to Incorporate the Town of Indianapolis in the County of Marion* (1838). After treatment. The text block is very flexible and moves easily.

with a decorative border around its perimeter. The text block was composed of two-folio handmade paper sections with relief printed text and engraved illustration plates depicting various surgical implements. These illustrations were incorporated throughout the text by a combination of tipped edges and stubs wrapped around inner folios and adhered to neighboring leaves. The sections were sewn around three sunken support cords using a two-on abbreviated sewing pattern. There were several annotations and William Guthrie's signature written in blue and iron gall inks on the first five pages of the text block.

The remaining original leather spine piece was heavily deteriorated and brittle, exhibiting red rot and severe cracking. The text block sustained heavy previous water damage and was stained and discolored throughout with many tide lines. The paper was also heavily soiled toward the front and back of the book, and several of the exterior-most leaves were torn and heavily creased. The text block was split and broken into three sections with several detached or tenuous leaves as a result of the breaks in the sewing. The engravings were heavily tipped to the text block leaves, which created stress points as the text block paper was quite thinner than the paper used for the illustrations (figs. 14, 15).

Once again, it seemed that this book required a full treatment that would include washing; however, testing revealed that the blue ink used for the annotations and signatures was extremely water sensitive and the iron gall ink annotations on the first two leaves were also problematic[2] (Jacobi 2011). Gellan gum seemed like an appropriate material to use to wash these pages, as windows could be cut in the gum to avoid the water-sensitive media (Maheux 2015). The two leaves containing iron gall ink signatures were left unwashed because they also contained the water-sensitive blue ink, and thus a phytate treatment would not have been possible. If gellan gum had been used to wash these pages, the visual difference

Fig. 14. *A System of Surgery, Volume 1* (1791). Before treatment. Front overall showing the split text block, staining, and annotations written in iron gall and blue inks.

between the washed and unwashed areas would have been very stark and distracting. It is not ideal to leave book pages unwashed, but it seemed to be a necessary compromise that was required in this situation.

Rebinding would be necessary after treatment, and given the thickness of the text block and the various paper weights throughout the book, a flexible binding was desirable that could be aesthetically sympathetic to the other two volumes in the collection. Volumes 2 and 4 of this work in our collection were published earlier, in 1785. Most of their original bindings remained intact, and therefore they were used as a reference for some of the aesthetic choices made during the rebinding of volume 1. Volumes 2 and 4 were bound in full brown leather, also with red spine title labels and gold-tooled spine lines. The gold tooling proportions were different from volume 1, and there were remnants of sewn endbands in plain cream-colored thread visible on one of the older volumes. Rather than using leather, a laminate of acrylic cast composite

Fig. 15. *A System of Surgery, Volume 1* (1791). Before treatment. Detached leaves and staining visible at the back of the text block. Similar tide lines were visible throughout the rest of the book.

leather (Owen and Reidell 2010) and cotton fabric was used for the spine piece. These materials tend to have better aging properties and with the use of cast composites can be made to look very convincingly like real leather (Minter 1985; Duffy 1989). Due to the lack of a mold large enough to create a sheet of cast composite leather to use for a full binding, paste paper was made using a pulled pattern typical of the late 18th century for use as the covering material on the boards. Gold lines were added to the spine in a similar proportion to the original binding using acrylic paint. A spine title label was created using a red piece of cast composite leather screen printed with the same gold acrylic paint used for the spine lines to mimic gold tooling. Printing and painting on the cast composite material was a more cost-effective method of mimicking gold tooling than purchasing sets of brass tools or other metal stamps.

TREATMENT PROCEDURE

1. After consolidating with 1.5% (w/v) Klucel G in ethanol, the original leather spine fragments were faced with gelatin-coated remoistenable tissue and lifted from the spine mechanically and with the aid of 2% (w/v) gellan gum applied through a layer of Hollytex. This was too much moisture for the leather, which did darken slightly, but it facilitated removal. The leather was extremely degraded and could not be removed without applying some moisture, as otherwise it would have crumbled completely. The slight color shift seemed acceptable to be able to remove the fragments in large pieces. The lifted leather spine was lined with Tengucho kozo fiber paper and encapsulated in polyester to be stored with the book in its enclosure.
2. The remaining adhesive residue was cleaned from the spine using a 4% (w/v) methyl cellulose poultice, then the book was disbound entirely.
3. The pages that contained the water-sensitive blue ink were lightly humidified in a humidity chamber and then washed between two sheets of 4% (w/v) gellan gum for approximately 40 minutes. Windows were cut into the top and bottom sheets of gum to avoid the ink annotations (fig. 16). The washed pages were dried between blotters and boards, and tide lines around the blue ink-containing areas were reduced by locally blotting the tide lines, front and back, with small pieces of 4% gellan gum until reduced (figs. 17, 18). The conjugate leaves that did not contain any ink annotations were washed in an immersion bath of filtered water for approximately 40 minutes, partially air-dried on a rack, then dried between blotters and boards. After treatment, it was not visually obvious that two different washing methods were used to treat these pages.
4. The rest of the text block was washed in an immersion bath of filtered water. Some of the more heavily stained

Fig. 16. *A System of Surgery, Volume 1* (1791). During treatment. Window cut into the gellan gum sheet to avoid the blue ink annotation. A corresponding window of the same size was cut in the bottom sheet of gellan gum to completely prevent moisture from touching the blue ink.

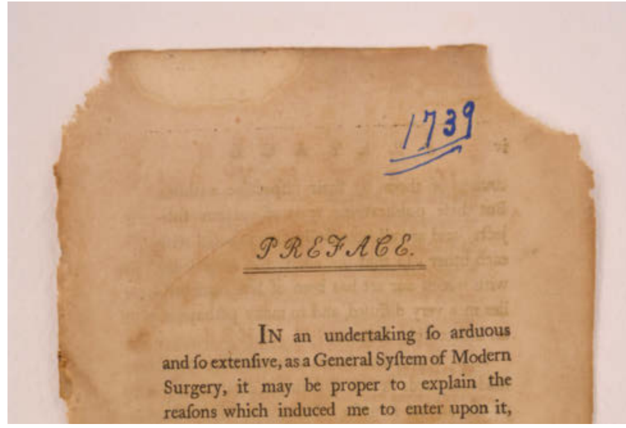


Fig. 18. *A System of Surgery, Volume 1* (1791). During treatment. The tide line has been minimized by dabbing it with a small piece of 4% gellan gum, drying between reapplication.

illustrations were washed a second time using TEK-Wipe to pull out more discoloration; however, most of the tide lines could not be fully removed. The pages washed in the bath were air-dried between Reemay on a drying rack.

5. The sections were mended and guarded with Kizukishi kozo fiber paper and Zen Shofu precipitated wheat starch paste. The heavily tipped illustrations were released during the bath and reattached to their corresponding sections with loose guards, sometimes using the original paper stub and sometimes extending these stubs with a strip of Kizukishi paper adhered with wheat starch paste. After guarding and mending, the sections were pressed between boards and light weight for about two weeks to flatten before rebinding.
6. Double-folio endpapers were constructed from Ruscombe Mill Stone Laid handmade paper toned with Golden acrylics to better match the color of the original text block paper. The text block was resewn two-on around three sunken linen support cords using the original abbreviated sewing pattern and original sewing holes.
7. The text block was rounded and backed, then lined with a reversibility layer of Kizukishi kozo fiber paper.
8. Volumes 2 and 4 in the set (dated 1785) still had remnants of white single front bead sewn endbands that were replicated on this volume. Despite guarding and mending, the text block remained too fragile for sewn endbands, so instead they were constructed off the book around a linen support and adhered to the spine with wheat starch paste in the manner of false endbands (fig. 19). The spine was then lined with an overhanging linen lining adhered with wheat starch paste.
9. New boards were constructed from two layers of four-ply museum mat board, as was done for the two

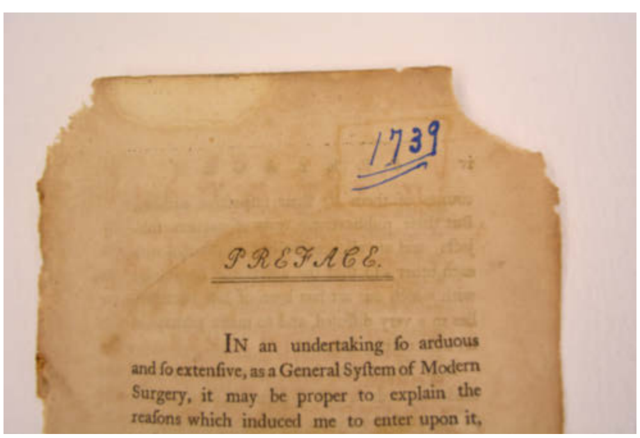


Fig. 17. *A System of Surgery, Volume 1* (1791). During treatment. Tide line after gellan gum washing.

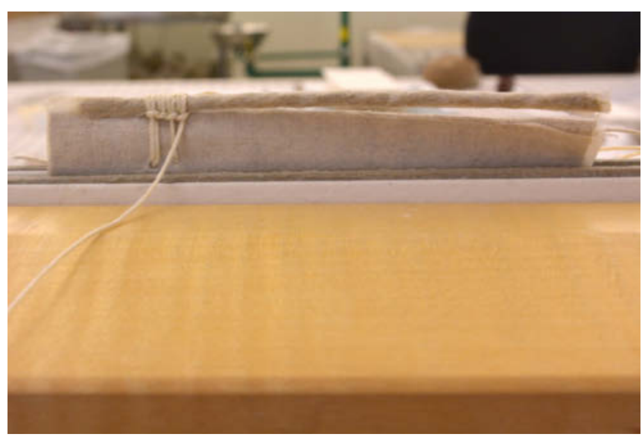


Fig. 19. *A System of Surgery, Volume 1* (1791). During treatment. Single front bead endband sewn off the book around linen cloth and a linen core stiffened with paste.

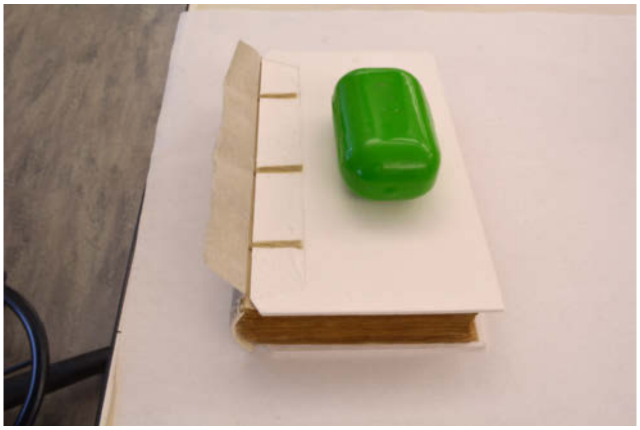


Fig. 20. *A System of Surgery, Volume 1* (1791). During treatment. Support cords inset into boards rather than twill tapes as described in the original Treatment 305 article.

Fig. 22. *A System of Surgery, Volume 1* (1791). After treatment. Front overall with view of screen printed spine title.

treatments described previously. Paste paper covering material was made from Golden acrylics and wheat starch paste on Mohawk machine-made paper. A pulled pattern was used, similar to historic 18th century paste papers.

10. Cast composite leather was made for the spine piece and was backed with Tengucho kozo fiber paper before laminating to light-weight cotton fabric with a mix of paste and Lascaux 498HV. A layer of Kizukishi kozo fiber paper was subsequently adhered to the back of the fabric with wheat starch paste.
11. The book was rebound using the Treatment 305 structure, except linen support cords were fanned out and inset into the boards instead of cloth tapes (fig. 20). The book was covered in a quarter style with the cast composite material and paste papers. The new binding elements and new pastedowns were adhered to the boards with a 1:1 mix of Jade 403 PVA and 4% (w/v) methyl cellulose.
12. A spine label was created using dark red cast composite leather matched to the color of the original label remnants. A screen printing technique using EZScreen was used to mimic a gold-tooled spine title label. 3 Blind lines were boned into the new spine material and inpainted with gold acrylic paint to mimic gold tooling lines in a similar proportion to the original binding and the remaining two 1785 volumes (figs. 21, 22, 23).

CONCLUSION

After using the Treatment 305 structure for three different treatments, its usefulness and versatility for rebinding books from the late 18th to mid-19th centuries has been clearly demonstrated. What began as an initial interest in trying a different treatment structure has turned into a favorite rebinding choice for books from this period. The options for aesthetic variation seem endless, and this structure also allows for easy

Fig. 21. *A System of Surgery, Volume 1* (1791). During treatment. Gold lines painted on top of the cast composite spine piece with acrylic paints after boning in blind lines.

Fig. 23. *A System of Surgery, Volume 1* (1791). After treatment. The book opens in a very flexible manner, and the illustrations can be easily viewed without creating stress points to neighboring leaves.

incorporation of original binding elements if desired. The adhesives can be varied and wheat starch paste can be used for all steps of the binding process, which is especially useful if many original binding elements are to be reused. The resewing method can also be changed, and original sewing patterns and similar supports can be used with successful results. This provides a structure closer to the historical binding but without the inherent weaknesses that are so often seen in bindings from this period. The resulting binding is stronger and vastly more flexible than typical late 18th to mid-19th century bindings and will be able to better withstand consistent use by patrons for many years to come.

ACKNOWLEDGMENTS

I would like to thank my colleagues at the Indiana Historical Society Conservation Lab, Ramona Duncan-Huse and Stephanie Gowler, as well as Rebecca Shindel, conservator at the Indiana State Library, for their support, encouragement, and discussions about the treatments presented in this article.

MATERIALS

Yame Kozo Hadaura paper
Talas
http://www.talasonline.com/about-us

EZScreenPrint
https://ezscreenprint.com/

NOTES

1. Since paste was used to adhere the original covering material to the new boards, there was a significant amount of pull being exerted on the boards after drying, which caused them to wing up and away from the text block. This two-step process of adhering the double-layer pastedowns helped pull the board back down toward the text block, thereby flattening them. If a second layer of pastedown were not available, an interior paper board lining could have been used before applying the pastedown to achieve the same result.

2. Washing documents containing iron gall ink can cause iron ions to migrate in multiple directions in the paper substrate, which can lead to future discoloration and damage. Ideally, a phytate treatment should be performed if an iron gall ink-containing document is to be subjected to aqueous treatment. Since there were only two leaves with iron gall ink signatures, it was decided to forego washing or any aqueous treatment on these pages to prevent any risk of iron ion migration and subjecting two leaves to a phytate treatment for the sake of two signatures that were duplicated elsewhere in the book, which seemed extreme.

3. The label text was printed on a transparency that was used to expose a piece of EZScreen photosensitive screen (https://ezscreenprint.com). Heavy body and metallic Golden acrylics were mixed to match the color of the original gold tooling, and the text was screen printed onto the cast composite leather label piece. This piece was trimmed to size and adhered with Lascaux 498HV to the new spine.

REFERENCES

Baird, J., and M. Letourneaux. 1994. Treatment 305: A collections conservation approach to rebinding. *AIC Book and Paper Group Annual* 13: 1-4.

Brown, M., and L. Ogden. 1998. An experimental book structure for conservation. *AIC Book and Paper Group Annual* 17: 77-81.

Duffy, M. C. 1989. A study of acrylic dispersions used in the treatment of paintings. *Journal of the American Institute for Conservation* 28 (2): 67-77.

Frost, G. 1982. Historical paper case binding and conservation rebinding. *New Bookbinder* 2: 64-67. 1982.

Haqqi, S. 2016. The rationale for rebinding at the Pierpont Morgan Library in the early 20th-century: A study of bindings by Marguerite Duprez Lahey. *AIC Book and Paper Group Annual* 35: 17-29.

Jacobi, E., B. Reissland, C. Phan Tan Luu, B. van Velzen, and F. Ligterink. 2011. Rendering the invisible visible. *Journal of Paper Conservation* 12: 25-34.

Maheux, A. 2015. Cross-disciplinary uses for gellan gum in conservation. *AIC Book and Paper Group Annual* 34: 69-79.

Minter, W. 1985. The use of linen as a book covering material. *AIC Book and Paper Group Annual* 4: 59-62.

Owen, G., and S. Reidell. 2010. Cast composites: A system for texturing repair materials in book conservation (handout). *AIC Book and Paper Group Annual* 29: 92-93, 98-105.

Tribolet, H. 1953. Binding and related problems. *American Archivist* 16 (2): 115-126.

FURTHER READING

Abbot, K. 2012. Bind-O-Rama 2011—Artistically reversible: Where conservation and art meet. *Bonefolder* 8, 87-99.

Appelbaum, B. 2011. Conservation in the 21st century: Will a 20th century code of ethics suffice? Paper presented at AIC's 39th Annual Meeting, Philadelphia, PA. http://barbaraappelbaumbooks.com/wp-content/uploads/paper_aic_conservation.pdf.

Conroy, T. 1987. The movement of the book spine. *AIC Book and Paper Group Annual* 6: 1-30.

Frost, G. 2006. Aesthetics of book conservation. *Bonefolder* 3 (1): 10-13.

Gledhill, C. 2011. Tomorrow's past. *Bonefolder* 7: 48-53.

Rhodes, B. 1995. 18th and 19th century European and American paper binding structures: A case study of paper bindings in the American Museum of Natural History Library. *AIC Book and Paper Group Annual* 14: 51-62.

Soleymani, S. 2015. The effects of plant dyes, watercolours and acrylic paints on the physical, chemical and biological stability of Japanese tissue paper used in paper conservation. Master's thesis, University of Canberra, Australia.

KATHY LECHUGA
Book Conservator
Indiana Historical Society
Indianapolis, IN
klechuga@indianahistory.org

Reducing Agent Tert-Butylamine Borane Complex and Its Use in Stain Reduction on Paper-based Artifacts

Stain reduction is sometimes a necessary but often ethically loaded consideration in the treatment of art on paper. From the standpoint of cellulose stability, reducing agents are considered preferable to their oxidizing counterparts as they have the potential to mitigate discolorations without further degrading the polymer backbone of paper artifacts. Although several oxidizing agents have been tried with paper substrates, sodium borohydride has long been the primary, if only, reducing agent. Recent work with gellan gum at the Canadian Conservation Institute has brought another reducing agent to the attention of paper conservators: tert-butylamine borane complex (TBAB). Explored by Italian researchers and conservators since the late 1990s, borane complexes show great promise as an additional tool for reducing paper discolorations but seems little known in North America. Several disadvantages of sodium borohydride (its tendency to evolve bubbles of hydrogen gas and the high working pH) are not present with TBAB, which shares borohydride's advantage of being soluble in both alcohol and aqueous systems. This paper will present the use of TBAB in the treatment of several watercolors by Canadian artist Lucius O'Brien, as well as on didactic paper artifacts. A discussion of the working properties, as well as the perceived advantages and challenges of using this reducing agent, will ideally familiarize more paper conservators with this relatively new reducing agent, broadening their choice of stain reduction agents.

CRYSTAL MAITLAND
Conservator, Works of Art on Paper
Canadian Conservation Institute
Ottawa, Canada
crystal.maitland@canada.ca

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

QUINN MORGAN FERRIS

Medium-rare: An Innovative Treatment Approach to the Space between General and Special Collections

ABSTRACT

This paper presents an overview of a new treatment workflow that was implemented in early 2016 at the University of Illinois Urbana-Champaign Library. Preservation professionals may be familiar with the idea of *medium-rare* within their collections—this term refers primarily to items that have exceptional material, historical, or condition characteristics that make them complicated to categorize beyond their collection designation. Adaptive conservation treatment approaches have long been employed in the conservation and care of library collections, usually administered on a case-by-case basis at the discretion of the conservator or technician performing the treatment. However, these treatment approaches for "in-between" materials previously have not been collected and formalized into a codified workflow. Having attempted to create a functioning workflow in the context of restricted resources and limited time over the course of a year, this paper will address the challenges and conditions that made the University of Illinois Urbana-Champaign Library ideal for piloting this new treatment approach. It will additionally address the formulation of parameters and limitations for treatment, as well as the infrastructure for tracking and documentation that was adapted and created to support the new workflow in the context of our existing conservation treatment approaches. Last, this paper will offer some insights on the benefits, challenges, and outcomes observed after its implementation, and provide a possible model for other institutions facing similar issues within their collections.

CONTEXT

The University of Illinois Urbana-Champaign (UIUC) Library is one of the 10 largest university library systems in the United States. The library collection contains 24 million items, 13 million of which are bound volumes. The undergraduate library alone has more than 200,000 volumes and provides in one location more reference resources for undergraduate instruction than any other undergraduate library in the country. Apart from that, the university is home to more than 25 individualized area libraries that house both circulating and special collections. Moreover, the Oak Street Library Facility provides high-density storage for items from multiple collections. Some of the more notable collections include the Sousa Archives and Center for American Music, the Illinois History and Lincoln Collection, numerous archival collections, and the Rare Book and Manuscript Library, which is home to the personal papers of John Milton, Marcel Proust, H. G. Wells, and Carl Sandburg.

As a result of having such robust collections, UIUC Library is often host to collection-focused exhibits and often loans collection material to outside institutions both within the United States and abroad. Additionally, the library works collaboratively on exhibits with on-campus institutions including the Krannert Art Museum and the Spurlock Museum of World Cultures. As a result of all of these exhibit opportunities, the pace of the exhibit calendar is kept at breakneck speed, with each curator managing his or her exhibits separately, so installation schedules and deadlines often overlap.

However, despite the fact that our collections and the opportunities to view them are vast and diverse, like many institutions the size of our collections largely outmatch the number of resources available. As a public university funded by the state of Illinois, UIUC has been severely impacted by the ongoing financial crisis that has resulted in a lack of budget for the past three fiscal years. The library has sustained cuts across all departments and has no capacity to hire many additional permanent staff members, even where there is a demonstrated need. In many areas of the library, when positions are vacated due to retirement, duties are shifted and reassigned rather than replenishing staff hours through new hires. Although the staff hours cumulatively decrease throughout the library, there is no decrease in the services provided to the university community.

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

The conservation unit, which operates within the preservation services department of UIUC Library, has served the library community on the second floor of the Oak Street Library Facility in the John "Bud" Velde Conservation Laboratory since the early 2000s and is staffed by two conservators; two technicians; and a constant flux of student volunteers, academic hourlies, graduate assistants, and interns. As a hybrid lab, we treat both general and special collection materials based on a wide range of need. Between May 2016 and April 2017, the library's conservation unit also prepared collection material for nine major exhibits. Due to the scope of the exhibits program throughout the libraries, it is a constant challenge for conservation staff to meet priority deadlines for exhibit materials and have time at the bench to deal with the ongoing needs of the rest of the collection. With a staff that is comparatively tiny to other library conservation programs of a similar size and scope, time is often at a premium.

In addition to balancing exhibit- and nonexhibit-related treatment, conservation staff are frequently attempting to mediate the needs of various collections within the limitations of time and resources. Thankfully, broader preservation issues such as disaster planning and preparedness, integrated pest management, environmental monitoring, and general rehousing are managed by Miriam Centeno, the collections care manager. However, although these preventative measures ensure that our collections are properly stored and generally well cared for, it has not diminished the backlog of items awaiting treatment. As a result, another challenge has been balancing the time-sensitive priorities of individual collections in such a way that all collections are receiving fair, if not equal, attention. Although the squeakiest wheel is often the one to get the grease, so to speak, conservation does its best to keep track of the necessities of various collections so that they can eventually be treated in time. Needless to say, this has continued to be a challenge.

ADDRESSING A LONG-ESTABLISHED NEED

NOT A NEW IDEA

Although these challenging conditions are by no means isolated to our institution, the confluence of all of them at once made UIUC Library a good case study for trying something new—both to seize the opportunity we saw and to attempt to ameliorate some of the more challenging aspects of our existing workflows.

In fact, a "medium-rare" workflow as a concept had been discussed by conservators at UIUC since 2008. In its infancy, however, the workflow took a decidedly different form than it ultimately would when finally implemented. The earliest specifications for medium-rare treatment were created by conservation in September 2009 and originally included the following:

- Treatment for any individual item will be completed in 2 hours or less.
- No written or photographic treatment documentation will be created for any item in medium-rare.
- No more than 10 hours per week total would be devoted to medium-rare.
- To begin, only bound items destined for Rare Book Oak Street storage would be considered treatment candidates.

To facilitate communication between conservation and collection managers without formal documentation, a "Medium-Rare Conservation Treatment Form A/B" was created in the form of a two-sided streamer, which could accompany each item that was sent to the lab. Form A (fig. 1) would have been filled out with requisite catalog information and treatment preferences by the curator or librarian making the request. Form B (fig. 2) would then be filled out by the conservator when the item was received, tracking the repairs completed on the text block and binding.

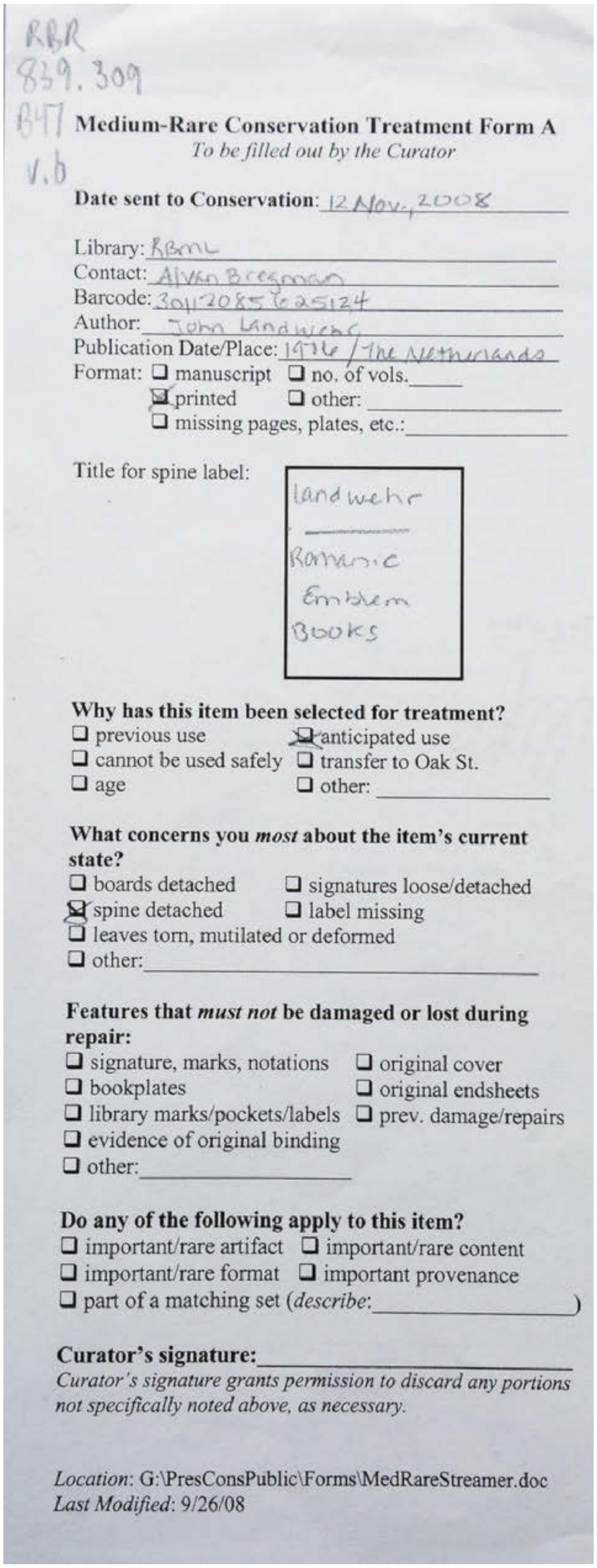
However, although much of the ground work was laid and revisited starting in 2008, it was not until 2016 that the lab moved toward serious implementation of a medium-rare workflow. This was primarily due to some of the constantly competing factors formerly stated—to begin a new workflow requires an initial investment of time and resources that was heretofore not prioritized within the context of other ongoing projects.

In the winter of 2016, staff began to notice an uncharacteristically dwindling stream of items for our general collection conservation workflow. Regardless of whether this sudden reduction was a momentary lull or a developing trend, the lab was running out of appropriate work to keep our technicians and student workers fully occupied. Meanwhile, in the midst of undergoing staff transitions, the conservators had the challenging exhibit schedule and an unending backlog to contend with. This moment seemed like a perfect opportunity to take advantage of newly liberated time for our technicians to accomplish treatments beyond the scope of the usual basic binding repair.

Given the volume of treatment work waiting, we were hoping that perhaps a new workflow would allow conservation to serve collections more widely by making batch treatment and other general repair options available to objects that had been otherwise difficult to prioritize given competing needs and limitations. More specifically, we thought it might give us the opportunity to address a long-existing need in library and archive conservation—namely, how to treat "medium-rare" materials, or items that have exceptional material, historical, or condition characteristics that make them complicated to categorize beyond their collection designations.

DEFINING *MEDIUM-RARE*

Just as the notion of a medium-rare treatment scheme was not new in our labs at UIUC, the concept of *medium-rare* as



RBR
839.309
B47
v.b

Medium-Rare Conservation Treatment Form A
To be filled out by the Curator

Date sent to Conservation: 12 Nov., 2008

Library: RBML
Contact: Alvan Bregman
Barcode: 30112085625124
Author: John Landwehr
Publication Date/Place: 1976 / The Netherlands
Format: ❑ manuscript ❑ no. of vols.____
☒ printed ❑ other: ____
❑ missing pages, plates, etc.:____

Title for spine label: Landwehr — Romanic Emblem Books

Why has this item been selected for treatment?
❑ previous use ☒ anticipated use
❑ cannot be used safely ❑ transfer to Oak St.
❑ age ❑ other: ____

What concerns you *most* about the item's current state?
❑ boards detached ❑ signatures loose/detached
☒ spine detached ❑ label missing
❑ leaves torn, mutilated or deformed
❑ other:____

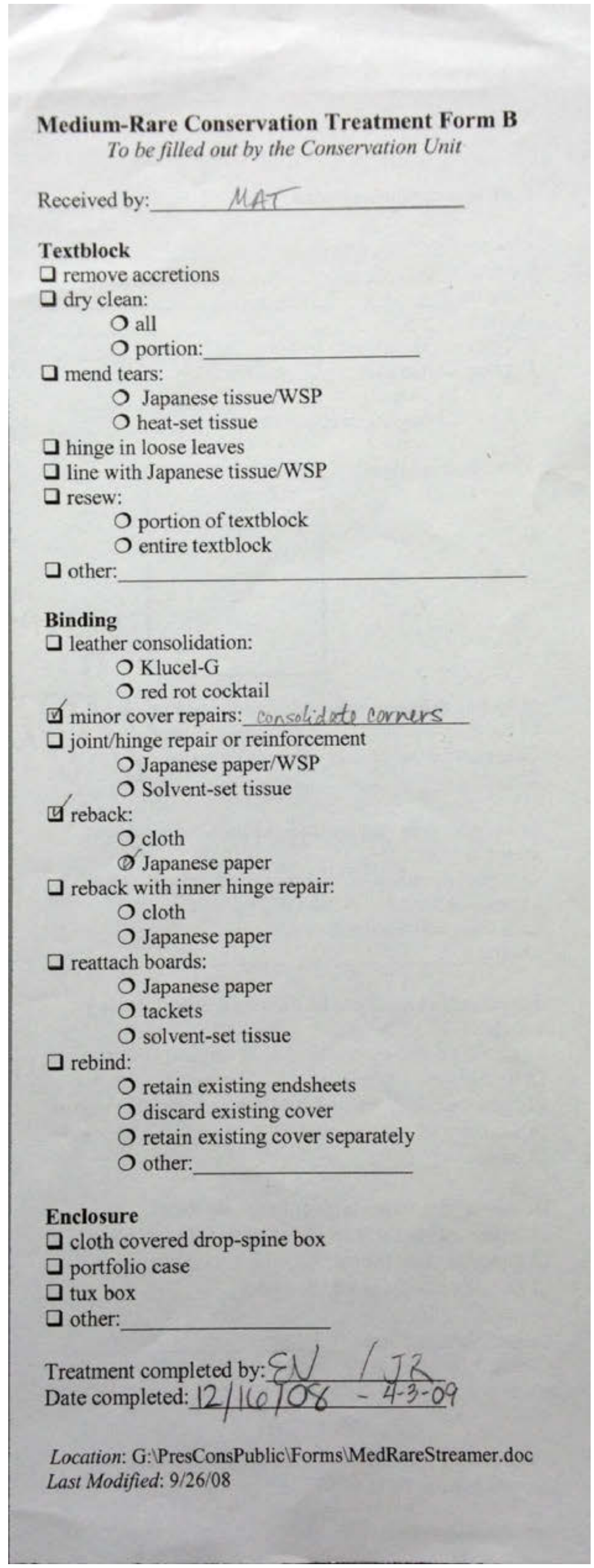
Features that *must not* be damaged or lost during repair:
❑ signature, marks, notations ❑ original cover
❑ bookplates ❑ original endsheets
❑ library marks/pockets/labels ❑ prev. damage/repairs
❑ evidence of original binding
❑ other:____

Do any of the following apply to this item?
❑ important/rare artifact ❑ important/rare content
❑ important/rare format ❑ important provenance
❑ part of a matching set (*describe*:____)

Curator's signature:____
Curator's signature grants permission to discard any portions not specifically noted above, as necessary.

Location: G:\PresConsPublic\Forms\MedRareStreamer.doc
Last Modified: 9/26/08

Fig. 1. Side A of the Medium-Rare Conservation Treatment Form streamer, for use by the collection manager.



Medium-Rare Conservation Treatment Form B
To be filled out by the Conservation Unit

Received by: MAT

Textblock
❑ remove accretions
❑ dry clean:
 ○ all
 ○ portion:____
❑ mend tears:
 ○ Japanese tissue/WSP
 ○ heat-set tissue
❑ hinge in loose leaves
❑ line with Japanese tissue/WSP
❑ resew:
 ○ portion of textblock
 ○ entire textblock
❑ other:____

Binding
❑ leather consolidation:
 ○ Klucel-G
 ○ red rot cocktail
☑ minor cover repairs: consolidate corners
❑ joint/hinge repair or reinforcement
 ○ Japanese paper/WSP
 ○ Solvent-set tissue
☑ reback:
 ○ cloth
 ⊘ Japanese paper
❑ reback with inner hinge repair:
 ○ cloth
 ○ Japanese paper
❑ reattach boards:
 ○ Japanese paper
 ○ tackets
 ○ solvent-set tissue
❑ rebind:
 ○ retain existing endsheets
 ○ discard existing cover
 ○ retain existing cover separately
 ○ other:____

Enclosure
❑ cloth covered drop-spine box
❑ portfolio case
❑ tux box
❑ other:____

Treatment completed by: EV / JR
Date completed: 12/16/08 / 4-3-09

Location: G:\PresConsPublic\Forms\MedRareStreamer.doc
Last Modified: 9/26/08

Fig. 2. Side B, for internal use by conservation to track treatment actions.

it applies to library collections is not new either. The earliest appearance of the term in professional literature can be found in an article by Ferguson (1987) titled "Rare Books in University Libraries," in which he discusses the application of the term at institutions such as the Library of Congress, where it was used as a designation to remove certain nonrare books from the "ordinary conditions of use" without completely removing them from the collection or necessitating more elaborate security and services as are required in rare book rooms. Since then, the term *medium-rare* has acquired several meanings and is often used to define items with regard to the selection and transfer of circulating materials to special collections when they are deemed materially significant but not valuable enough to justify a place in rare book collections. More recently, the terms *medium-rare* or *newly rare* have been used to refer to books within special collections that are less valuable but still pose security issues as targets for theft and resale.

Ultimately, the most general use of the term presently seems to be as a tongue-in-cheek catch-all to help librarians and curators identify books that fall within the "gray area of rareness" without pigeonholing a volume based on its age, composition, or relative uncommonness. This, however, still does not offer up a solid definition. Although libraries as institutions often intensely focus on the classifications of their materials, "medium-rare" remains a loophole to categorize what is otherwise difficult to classify.

For the purposes of this project, the definition of *medium-rare* was less concerned with rarity, security, or formal classification within MARC records and more toward developing the term with respect to treatment approach. "Medium-rare" identified items that were a lower priority for treatment, and whose treatment needs did not stray too far beyond general book repair. This included both special collection items where treatment was quick, simple, or otherwise straightforward, as well as general collection items that might not have been highly valued but had unusual or notable material features and therefore called for a higher level of retention or care.

Sensitive to the fact that most library conservators were probably familiar with this category of items, Jennifer Hain Teper sent out a broad query via several professional distribution lists in December 2015 to get a sense of what approaches, if any, our institutional peers were already taking with regard to conservation treatment. Specifically, respondents were asked:

- What sorts of materials typically fall into this workflow, and how do you delineate this category of treatment?
- What level, if any, of photo documentation do you conduct?
- Do you involve curatorial approval of treatments as part of your process?

The overwhelming sentiment of the few responses received was that there was little to no formal effort to separate out treatment procedures on these types of materials from the rest. More often, items falling into the medium-rare category were treated on a case-by-case basis, with the conservator or technician making decisions on the level of documentation needed or the types of repair materials utilized at their own discretion. Indeed, this was the treatment approach used by UIUC's conservation lab as well prior to formalizing the medium-rare workflow in February 2016.

TARGETING OBJECTIVES AND DEVELOPING A WORKFLOW INFRASTRUCTURE

As staff began to consolidate treatment practices into a codified workflow, the goals became clearer. Staff had to develop a treatment approach that could finally meet the long-standing need for "in-between" collection items and hoped that this would simultaneously magnify the scope of impact on the number of items treated and the variety of collections served. This would also hopefully allow the unit to make best use of the qualified technicians and their newly liberated time. Additionally, staff were interested in seeing whether or not they could reduce the number of competing priorities for our two staff conservators. Last, staff wanted to organize a consistent approach to treating medium-rare library materials, both flat and bound, that could be used as a model for other institutions.

UTILIZING ESTABLISHED PROCEDURES AND CREATING NEW ONES

In many ways, staff were fortunate in that they knew many of the already existing procedures in both general and special collection treatment workflows would remain relevant and functional for medium-rare. To begin with, transporting medium-rare items to and from the conservation lab was easily facilitated through the existing relationship with the library's shipping department. Items could be packaged in predelivered totes and could often be picked up within 24 hours of a request for transport (fig. 3). This required minimal coordination between the conservation lab, library shipping, and the originating collection.

Documentation was another area where staff relied heavily on already established processes. Although prior iterations of the medium-rare workflow called for no required photo or report documentation, it was felt that some documentation was necessary to adapt and record medium-rare treatment practices, especially since the intention was to broadly apply these practices to items within the library's collections.

Communication was aided by the documentation database, a web-based platform that was built in-house for custom use at UIUC. A major benefit of the database is that it

Fig. 3. Library shipping "totes" outside the conservation lab awaiting transport.

is able to pull an item's bibliographic record from Voyager—the library's cataloging software—via barcode scanning. Practically speaking, this meant that catalog information could be automatically populated into our documentation forms (fig. 4), which saved significant time when preparing reports. However, if a medium-rare workflow was to be successful, staff knew that they would have to streamline documentation processes more significantly, particularly with regard to the use of narrative description for individual objects. Working with the library's software developer, we created a new medium-rare interface that replaced narrative description fields with short-form categorical checkboxes. Using the checkboxes, a conservator could quickly specify if an object was bound or unbound, if paper was laid or wove, if a binding was leather or cloth, and so on (fig. 5). This interface, which operates more like a brief object assessment, was intended to furnish a snapshot of the object treated without taking up too much time spent on the process of reporting.

Another important feature of the database was the way in which it enabled conservators to communicate with collection managers about items in the lab. As is standard practice among conservators, submitting proposals for review and approval to a curator or librarian is a regular function of a special collection conservation workflow. Previously, staff relied on the database's automated function for submitting a condition report or treatment proposal to a specified collection manager, allowing for easy, automatically archived communication between the conservation lab and owning libraries. Since medium-rare was a new treatment approach, it was felt that maintaining the practice of submitting proposals to collection managers for approval was an important step in preserving trust and fostering understanding.

Fig. 4. Bibliographic information imported into a treatment record via Voyager, made accessible through the interface of our documentation database.

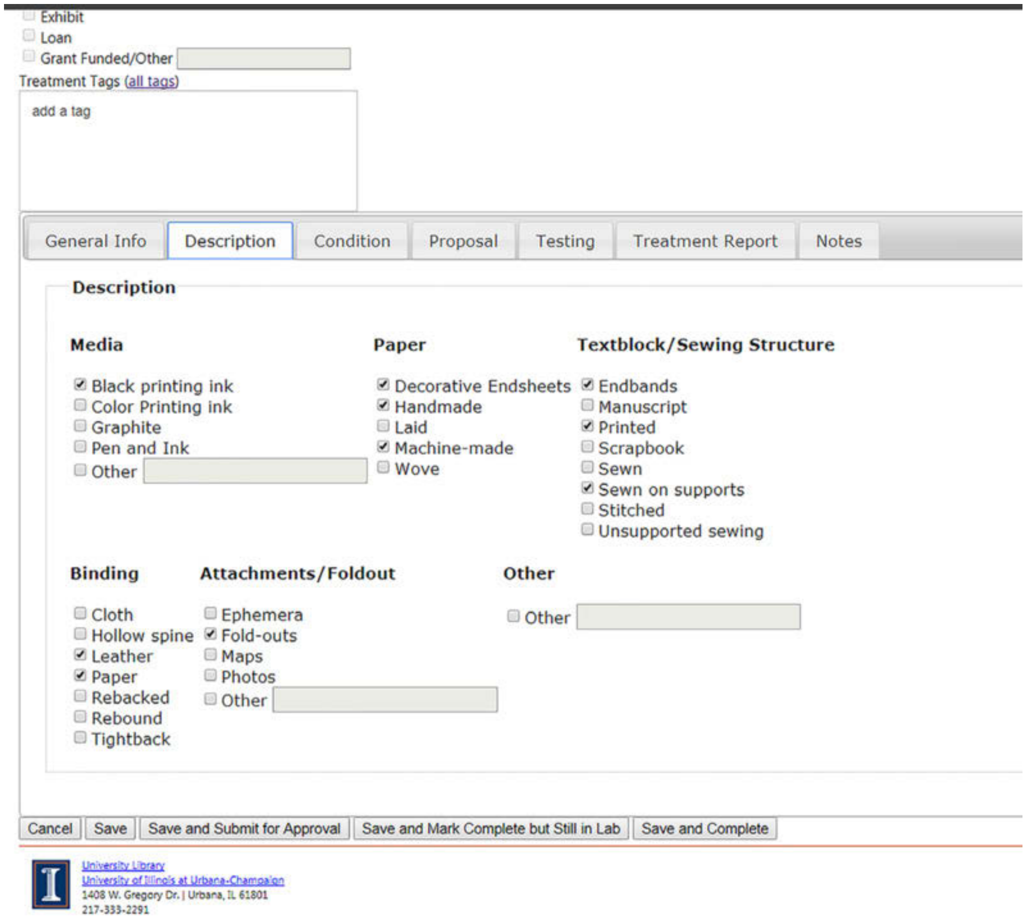


Fig. 5. Another view of our database, showing the abbreviated documentation description used for medium-rare assessment prior to treatment.

Likewise, the established protocol for photo documentation was the starting point for a truncated medium-rare approach. We retained processes for image capture, file migration, and management, as well as the operational use of the designated photo documentation space within the conservation lab. However, instead of taking numerous images to represent the condition of the object to the fullest extent possible, we limited the number of shots per item to the following (fig. 6):

- Front or front cover of the object
- Back or back cover of the object
- One to three shots of "representative damage."

To further simplify the process, staff eliminated the standard ¾ view of bindings (fig. 7) for representing the edges and spine. This eliminated the need to switch between the use of a copy stand and a tripod, which saved significant time during the photo documentation process. We also decided not to shoot objects in transmitted or raking light, as it was assumed that these treatments would be minor enough that such documentation detail would not be necessary.

As the workflow developed, staff began to see occasional treatments for which photo documentation was not needed. Staff therefore gave themselves the option of forgoing it. This usually was in the case of certain minor treatment actions that might be done in situ, such as removing something from an old pamphlet binder or repairing a few minor edge tears—repairs that were fast and simple enough to not require going over to the lab. Of course, the option to proceed without photo documentation was only completed subsequent to consulting with collection managers about the reasons and risks.

WHAT MEDIUM-RARE IS *NOT*

As difficult as it was to clearly define what medium-rare is, it became obvious what medium-rare was *not* early on in the process of identifying potential treatment candidates. Treatment approaches that were categorically complex and challenging were excluded from consideration. This meant that any objects requiring these treatments would by definition have to be excluded from the workflow. For example, treatment involving the use of solvents for adhesive reduction or stain

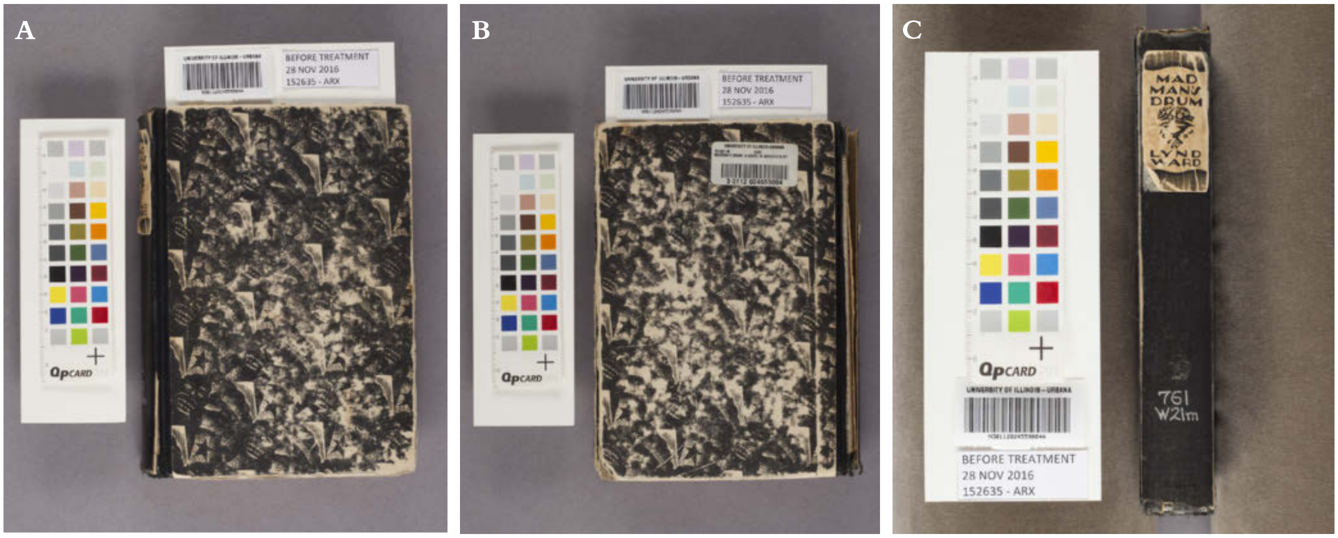


Fig. 6. (a-c) Limited before treatment images used in the medium-rare conservation workflow.

removal was considered too high risk to be completed without the supervision or direct involvement of a conservator. Likewise, any items that required the paring, tooling, or specialized working of leather would have to be excluded as well. Moreover, any items that featured compound or problematic material features such as parchment and certain photographic emulsions were also not considered for medium-rare treatment, in part due to their difficult material features (rather than the complexity of the treatment approach), which made them risky to work with without close supervision from a conservator (figs. 8, 9).

Most, if not all, of the usual medium-rare treatment options were based on lab practices for general collection repair. This included basic spot-sewing and resewing, mending, hinge tightening, spine cleaning and consolidation, board reattachment, and retaining old cases or creating new ones. However, from a material point of view, it was necessary to alter the approach to reflect the standards typically applied to special collections materials. Whereas staff might use polyvinyl acetate in lining a spine for circulating collections repair, we used wheat starch paste for medium-rare. Tissue mending was done with water-torn Japanese tissue and diluted paste rather than heat-set tissue. Original components were retained wherever possible, and all treatments were approached with “reversibility” in mind.

IMPLEMENTATION

Once staff identified goals for the workflow, developed the infrastructure to support it, and figured out the parameters of what was to be treated, there was nothing left to do but begin. The first step was simply to start a lot of conversations

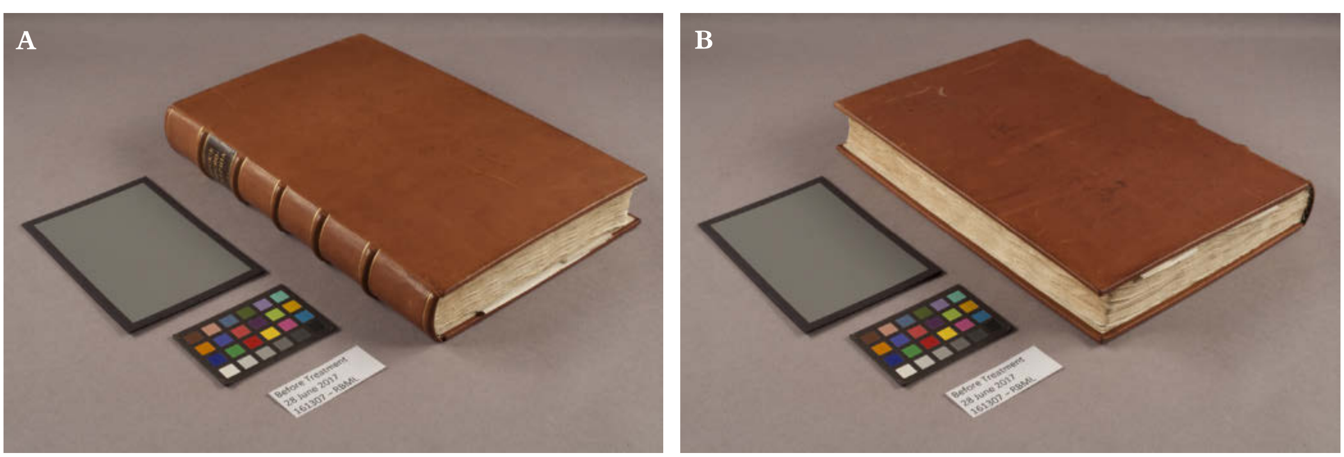


Fig. 7. (a, b) Using ¾ shots of volumes for special collection photo documentation is preferred because it is able to capture all edges on the spine but is not used for medium-rare.

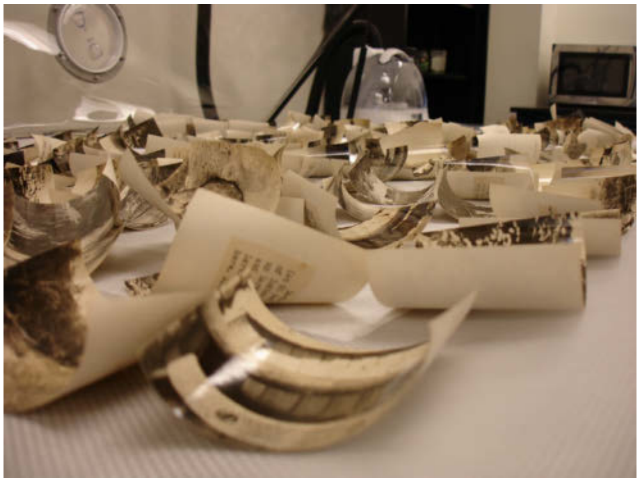


Fig. 8. A collection of curling photos in need of flattening and rehousing. Although fairly straightforward, this treatment approach would not be identified for the medium-rare workflow due to the risks and experience required for handling photographic emulsions.

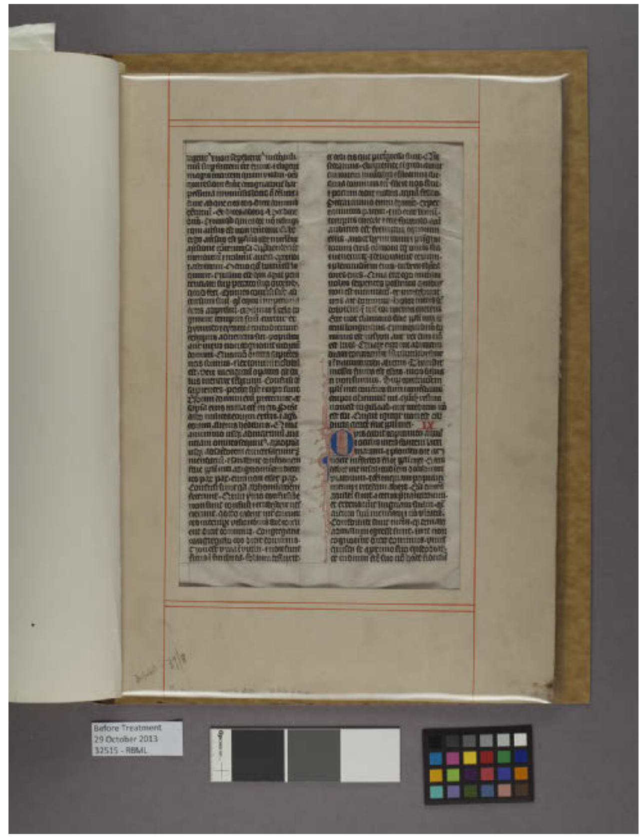


Fig. 9. Because the organic structure of parchment makes it highly reactive to its surrounding and can often present challenges in treatment, it also was excluded from medium-rare.

throughout the library. Conservators began "plugging" medium-rare conservation as a potential treatment option during routine priority meetings among various collections, simultaneously noting any objects that might be appropriate for transportation to the lab for medium-rare treatment. In the early stages of implementation, conservators operated as the primary point of contact with the collection managers. They established review meetings to look at objects and suggest treatment options, using each object as an example to explain the differences between the possible workflows. When medium-rare treatments were completed for one collection, conservators shared the before and after documentation with curators from other collections to give them a sense of what could be expected, as well as to alleviate any resistance born from protective instincts.

To keep the medium-rare workflow moving, it was necessary to set aside weekly time for both the logistical administration and coordination of medium-rare materials, as well as the practical hands-on time at the bench. Staff members dedicated one to two days to working on treatment and managing the workflow. It also became important to allow for flexibility in the infrastructure—although the new database was successful in reducing the time needed to complete written documentation, initial omissions or operating errors made it less than optimal at first. Staff used paper assessment forms that could be added to the online database later as needed.

BENEFITS

Almost immediately, staff began to observe some major benefits as a result of the addition of the medium-rare workflow. Working relationships with collection managers around the library were immediately augmented by the higher level of communication, and soon collection managers who in the past had felt as though their collections did not receive enough attention started to look at their collection needs with a mind toward what might be able to be treated under this new designation. The faster turnaround time for treatment certainly helped—whereas for conservators the special collection treatments were taking between 6 and 12 months to finish, the medium-rare items coming into the lab were seeing an initial turnaround time of closer to 3 to 4 months. This quicker rotation meant that collections could get their materials back faster for use in classes and reading rooms.

Corollary to that, because objects were spending less time in the lab, staff were seeing a broader range of collections served than had been seen previously. This was concentrated within two or three library collections that had been historically underserved. However, the ability to prioritize their materials for treatment meant that items long in need of treatment were finally receiving it.

As was hoped, the medium-rare workflow allowed technicians to focus on treatments that required more time and somewhat more complex decision making rather than typical general collection repair. As an added boon, having technicians perform these treatments reduced the backlog of items waiting for the attention of one or both of the conservators.

The least anticipated benefit came in the form of being able to create a new stream of work that could potentially be appropriate at a student or intern level. UIUC's conservation lab has long been recognized as a teaching lab, engaging students at all levels of education, experience, and interest. Having a new lifeline to seek out medium-rare items allowed us to clearly identify discreet projects for students working in the lab. For those who planned to continue studying conservation, we were able to find and designate treatments that both augmented their portfolio and were at an appropriate level for them to accomplish.

CHALLENGES

Although the benefits were immediate, the new workflow was not without its challenges. Early attempts at describing what "medium-rare" treatments actually consisted of were as convoluted as previous attempts to define it within this paper. Other than suggesting to collection managers that "you'll know it when you see it," it was important to build confidence and knowledge in their abilities to understand and identify what conservation staff were specifically looking for—especially if they were going to be expected to independently designate which items were coming to the lab for treatment. However, this also meant that staff in conservation had to learn when to judge that placing the responsibility on the collection managers was actually too much and was slowing our processes down as a result. Having numerous meetings to try and establish what could be considered medium-rare might not be the most efficient use of anyone's time if the decision on treatment approach could more easily be made by conservation once the item was in the lab.

To that end, throughout the implementation process, it was important to learn staff limitations on an individual basis—which really just meant adjusting to the learning curve of each individual staff member. Previously, conservators and technicians operated predominantly within one workflow, whether it was special or general collections. Working in medium-rare meant that staff had to change their approaches and develop more versatility to expand their holistic knowledge of what goes on in the lab. This, in turn, would hopefully enable a better understanding of the parameters of the new workflow. Doing so was contingent on frequent communication in the form of biweekly check-in meetings, where staff all applied a constant revisionist eye toward the aspects of the workflow that needed improvement.

One of the biggest challenges early on in implementation came in the form of balancing the new workflow's administration with respect to already existing workflows within the lab. Although staff were seeing more treatment happening, the time it took to establish and administer the workflow actually took time away from the bench rather than adding to it, especially with respect to the conservators. Although the conservator was the primary point of contact for the collection managers in the beginning, it soon became apparent that it was more efficient to have the staff member completing treatment in direct contact with the collection manager from the owning library. It is possible that this would be a hurdle with implementing any new treatment methodology, as the initial investment of time and resources to get it moving is always most significant in the beginning.

There was also resistance encountered while proposing the medium-rare workflow. The most interesting example of this came in the reaction of certain collection managers to the *medium-rare* terminology itself. To conservation staff, medium-rare was not an assignation of value or priority of the object but rather a means to classify a treatment approach for particular materials. However, for some curators, having their items categorized as such felt as though conservation staff were diminishing the "specialness" or rarity of their special collections, and working to allay the fears that that terminology introduced could sometimes be an obstacle. Internally, staff have wondered if it would have been better to use more neutral or objective language, such as treatment levels 1 through 3, to designate treatment streams rather than using the loaded terminology of *special*, *medium-rare*, and *general*. This may be an important consideration for other institutions that might be interested in implementing some form of medium-rare treatment within their own collections. However, after months of campaigning on the platform of medium-rare, UIUC staff have concluded that changing the name at this point would only muddy the waters.

OTHER AREAS OF GROWTH

As it turns out, one workflow can apparently beget many other workflows. Once the medium-rare treatment workflow was in steady swing, staff began seeing other areas of our processes that needed more formalized attention. For example, staff found that having a confluence of so many collection items from various locations with multiple treatment routes really called for the creation of a more standardized request form. In consultation with the rest of preservation services and using a custom-designed Google Form, we launched an online conservation treatment request form in spring 2017 (fig. 10). The request form gathers initial data such as bibliographic information, repairs needed, whether the item is for exhibit or digitization, and the date when treatment needs to be completed. This allows collection managers to build a queue of items in one location and allows conservation staff to keep track of whose collection is receiving treatment at any given time.

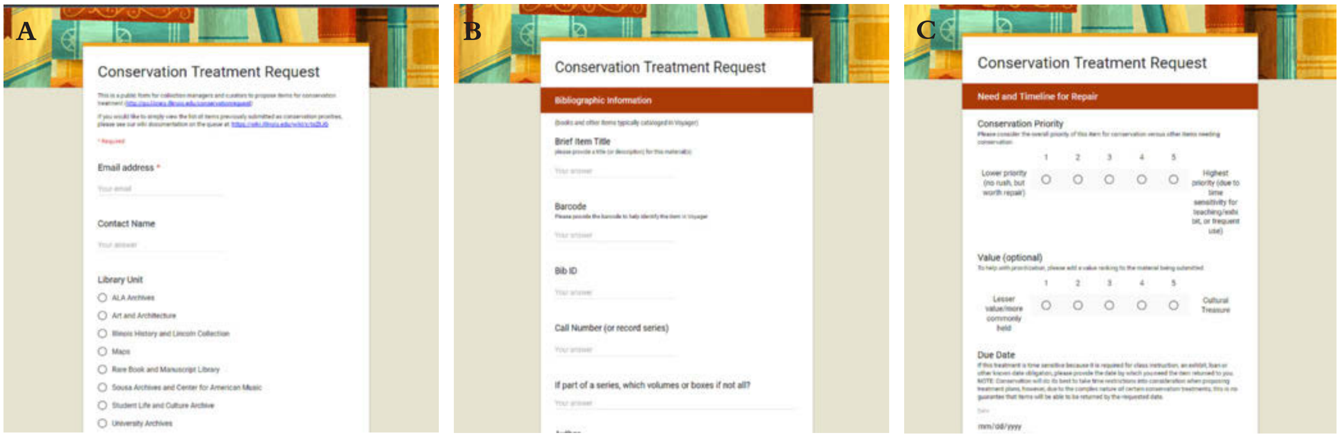


Fig. 10. (a-c) Views of our web-based conservation request form.

Another example of new workflows was developed as a result of rethinking the photo documentation setup. One of the main motivations for the medium-rare workflow was to increase productivity. However, a new accumulation of material to be photographed slowed staff down significantly. Someone was constantly needing to photograph something to keep the other stages of the workflow moving along. To deal with this, staff created a new graduate position—photo documentation coordinator—to handle the many aspects of the photo documentation setup. The inaugural student, hired in spring 2017, has been trained in safe handling of rare and delicate materials, as well as the standards of conservation photo documentation (fig. 11). This position is responsible for completing image capture, file migration and management, as well as the consolidation of our documentation *about* our documentation processes, so that training and knowledge can be easily transferred to the next student to hold the position.

Additionally, in the course of having to promote the medium-rare treatment workflow around the library, Preservation Services as a whole thought it might be a good time to reprise a former practice of conducting site visits to all of the area studies collections throughout the university library system. This would give them an opportunity to touch base with campus libraries with whom they have less frequent interaction to let them know of new services that may be beneficial to them. These site visits were also implemented in spring 2017.

Being able to track more minor treatments in the medium-rare database also aided in the concurrent development of a new plan for in situ conservation at the Rare Book and Manuscript Library. The goal of this plan is to create a secondary conservation space within the main library on campus to broaden the number of basic treatments able to be completed without requiring transport to the lab. Furthermore, being able to hold regular office hours, answer routine questions, and offer higher availability to curators will hopefully deepen working relationships and improve communication overall.

CONCLUSIONS

Between September 2016 and May 2017, the conservation lab at UIUC had completed a total of 90 treatments designated as medium-rare. Staff currently do not have a reliable way to

Fig. 11. Sushant Sapre, our inaugural student in the capacity of photo documentation coordinator, taking light readings before image capture.

capture a data metric regarding the percent increase of treatment across various collections, nor a means to quantify the exact types of treatments that were seen within the medium-rare workflow. However, anecdotally, staff are able to report that collection managers seem to both recognize the efforts staff are making toward caring for their items and are deeply appreciative—this may be arguably more important than data metrics. An aspect of working in an institution where every position and department is working with limited resources is that everyone can become keenly aware of others' needs and stresses. As conservators, we are deeply concerned with objects and their care—often this is what draws us into the conservation profession to begin with. However, as library conservators, we are additionally concerned with the use of these objects, and with supporting the people who facilitate that use. By empowering that connection, we make room to create unique learning experiences for users and staff alike.

Medium-rare treatment as an independent workflow is still in its infancy, but with continued diligence and work, the staff at UIUC hope that it will continue to thrive and provide an opportunity to update the conservation community on longer-term outcomes.

ACKNOWLEDGMENTS

The author wishes to thank the AIC and the Book and Paper Group for inviting her to present this information at the AIC Annual Conference. Special thanks go to the following individuals for their hard work, contributions, and support: Jennifer Hain Teper, Cher Schneider, Jody Waitzman, and Marco Vinicio Valladares Perez. Additional thanks are extended to Laura Larkin for her early work on establishing a medium-rare workflow, as well as our library colleagues who patiently worked with conservation as we went through the trial and error of beginning something new: Miriam Centeno, Melanie Emerson, Krista Gray, Bill Maher, Bethany Anderson, Travis McDade, Caroline Szylowicz, and Eva Miller. Finally, thanks to the students who supplied enthusiasm and provided valuable feedback: Alexandria June Jones, Kathryn Vespa, Sushant Sapre, Jennifer Zhong, and Claire Gianacakos.

REFERENCE

Ferguson, S. 1987. Rare books in university libraries. *Library Trends* 36 (1): 157-169.

FURTHER READING

American Library Association. 2012. The nation's largest libraries: A listing by volumes held. ALA Library Fact Sheet 22. http://www.ala.org/tools/libfactsheets/alalibraryfactsheet22.

Bosman, J., and M. Davey. 2017. 'Everything's in danger': Illinois approaches 3rd year without budget. *New York Times*. https://www.nytimes.com/2017/06/29/us/illinois-state-budget-impasse.html.

Potter, S., and R. P. Holley. 2010. Rare materials in academic libraries. *Collection Building 29 (4)*: 148-153.

Riley, J. D. 2008. Library marketplace: Medium rare books, POD wars, instant books brought to you by algorithms: Here's the scoop. *Against the Grain* 20 (3): 55-58.

Rinaldo, K. 2007. Evaluating the future: Special collections in art libraries. *Art Documentation* 26 (2): 38-47.

Teper, J. H. Conservation treatment request. *Google Forms*. Accessed August 15, 2017. https://docs.google.com/a/gm.slc.edu/forms/d/e/1FAIpQLSeK6yz-fE-pTYkJpkfRM-cwJavvmRxzazKODSZ89TX5Ej2XG_w/viewform.

University of Illinois, Urbana-Champaign. Academic resources. *Illinois Facts*. Accessed August 15, 2017. http://illinois.edu/about/facts.html.

QUINN MORGAN FERRIS
Rare Book Conservator
University of Illinois Library
Champaign, IL
qferris@illinois.edu

Recapturing the Subtleties

INTRODUCTION

If one thing is well established in the literature, it is that paper conservation is a delicate balancing act. The paper conservator weighs treatment considerations heavily, first and foremost regarding whether the artwork in question should be subjected to intervention. The deciding factors are numerous, but among them are the availability of tools to solve the identified problem and the conservator's confidence to use them. This paper will focus on the problem of staining and discoloration in paper, as well as the parameters of treatment options currently available to affect these problems.

The nature of staining can be vast, with internal and external culprits. Much study has gone into identifying the specific components of stains, from tide lines to foxing to light exposure, among others. Stains and discoloration are qualified by the custodian: sometimes valued and retained as evidence of the life of the object, and other times considered an aesthetic blight or physically destabilizing element that must be removed. Often it is left to the conservator to decide the safety and reasonability of stain removal, given the range of the evidence the conservator has gathered during examination.

The solutions to condition concerns can be thought of as a set of tools in a toolbox. The paper conservator's toolbox has expanded over the years, and the techniques that will be described constitute an addition to the array of devices that are already present. A good tool becomes more familiar over time, wears nicely, and becomes second nature to the user. The methods presented here are meant to be complementary to those that paper conservators already use.

BALANCING THE RISKS

The responsibility of caring for art is given to conservators because they have been taught a variety of ways to deliver this care, ranging from removing an artwork from view in an effort to preserve for the future to treating severe damage in an effort to restore the object to its aesthetic or physical balance. In between, conservators have a wide range of treatments with a wide variety of deciding factors: the skill of the conservator, the decided level of intervention, and the tools available to perform the task. Sometimes these factors are also dictated by the personality of the conservator, as well as the conservator's treatment evolution and approach.

The discussion begins on the scale of intervention—that is, where treatments fall on the continuum of invasiveness. It is common for a practicing conservator to come across someone else's treatment of an artwork; their reaction to that treatment, and the realization that someone will likely encounter the conservator's treatments in the future, checks the degree of willingness to intervene.

In Irene Brückle's essay *Aqueous Treatment in Context* (Banik and Brückle 2011), she expertly outlines the considerations and conundrums that the paper conservator faces in composing a treatment plan. She establishes that "treatment abstinence" can cause as much harm to the object as active treatment, and that conservators' decisions carry risks and benefits that vary based on the context of the artwork and the specific condition of the piece in question. Reminders of the artwork's physical characteristics, and their relationship to each other, are critical to the decision-making process, which Keiko Keyes astutely recognized early in paper conservation's history: "The interplay of the paper with the medium is always crucial to the visual effect. In treating works of art on paper we must be aware of the subtle qualities of texture, tone, and three-dimensionality that they have, and adjust our methods of treatment to preserve these qualities" (1978, 6).

These subtle characteristics, or rather the paper conservator's recognition of them, are what helps the conservator formulate a treatment that is respectful of the artwork and the passage of time.

TREATMENT OBJECTIVES

This paper will deal specifically with the treatment considerations of stains and discoloration within paper conservation. It will not be an attempt to scientifically evaluate the reduction or removal of stains; rather, an exploration of treatment nuance and intuition will be investigated in an effort to

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

illustrate the theories of new techniques of stain reduction. With this in mind, three goals in treatment of stains have been identified:

» *Treat stains efficiently and effectively.* Treatments should be reasonable in time, considering the duration of intervention and the expectation of the custodian. The damage should be aesthetically reduced or physically removed.
» *Retain as much original material as possible.* To conserve infers retention of the original. Every effort should be made to only remove evidence of damage, striving to leave as much as possible untouched.
» *Consider the interaction of the media with the paper.* The artwork is not singular in its materiality, and treatment of one component must take into consideration the whole object.

A certain genre of treatment techniques can be identified as "all-in"—that is, intrusive and irreversible. Others can be slow and steady, with changes nearly imperceptible between applications, but still effective. The conservator learns to identify unique characteristics of treatment techniques and balance them based on the situation. The power of control is paramount, and knowing when to stop is perhaps more important than knowing when to press forward.

CONSIDERATIONS

One of the essential points that is emerging as a key component of treatment with subtlety and control is conductivity. Hughes and Sullivan (2016) have explained the concept of conductivity and how the conservator can adjust it within a solution. To give a brief explanation, conductivity is a measurement of how well an aqueous solution conducts electricity. It is conductive only when ions are present, so it is inferred that when there is no, or very low, conductivity, there are very few ions. When there is high conductivity, the ions within the water are also high.

Figure 1 shows a chart of solutions that are commonly used in paper conservation. For a point of reference, the typical conductivity of the surface of paper is between 50 and 250 microSiemens/cm when measured with an agarose pellet, depending on the damage and the components of the paper. Notice that these numbers fall into two different ranges: low with the aqueous solutions, and high with the chelators and a reducing bleach. This serves as a point of reference to start thinking about the conductivity of the treatment materials used by paper conservators.

Conceptually, then, conservators consider conductivity and how it relates to the artwork, and how it relates to the damage that they are intending to treat. The term *tonicity* refers to the idea that two solutions have ionization, and how they relate to each other falls into three categories: hypertonic, hypotonic, and isotonic. A hypertonic solution has more ions than the other solution, whereas a hypotonic solution has less. Isotonic solutions have more or less equal ionization. The idea is that ions within a solution prefer to find equilibrium.

Aqueous Treatment Solution	Conductivity
Deionized water	0 µS/cm
Calcium Hydroxide in water, prepared to pH 7	6 µS/cm
Ammonium hydroxide in water, prepared to pH7	2 µS/cm
Diammonium Citrate, 1%	7.3 mS/cm
Triammonium Citrate, 1%	9.2 mS/cm
Sodium borohydride, ¼%	5.8 mS/cm

Fig. 1. Selection of solutions used in paper conservation.

Many paper conservators have been taught that washing paper in deionized water can adversely affect the paper and media, which is one of several reasons that water is conditioned with a salt such as calcium, magnesium, or ammonium hydroxide. With the additions, conservators are trying to stabilize the pH, exercising a degree of control on the aqueous solutions. After years of study comparing washing in deionized water versus washing in calcified water, the latter has proven to be more beneficial to the paper, increasing fold strength, reducing acidic by-products, and generally improving the aesthetic result more than that of washing in deionized water. The merits of conditioning aqueous treatment solutions are indisputable.

However, consider what have been identified as the subtleties of a work of art on paper. Going back to the chart of conductivity of solutions (fig. 1), it is apparent that paper conservators are using things that are very hypotonic or very hypertonic on paper, media, and stains. In certain treatment circumstances, introducing high or low ionic activity is quite useful. But consider what benefits there might be if one could use an aqueous solution that matches the conductivity of the paper, media, or both. Soluble acidic by-products would certainly still be taken away from the artwork, as it is in an aqueous solution. Hydrogen bonding will still be restored within the cellulosic structure. But because the solution is close in conductivity to the paper and its components, the possibility has increased that original material such as sizing has been mostly retained within the paper. More importantly, the amount of swelling in the paper is significantly decreased, allowing better retention of the original surface and less likelihood that the media will sink or otherwise be affected by structural changes in the sheet. Furthermore, by using controlled application of chelators in gels, staining materials can be physically removed rather than simply decolorizing them with a bleaching agent.

This system for the treatment of stains and/or discoloration on paper can be broken down into several elements, each of which can be adjusted to suit the need of the artwork. The elements are pH, conductivity, delivery method, and modifiers. The pH and conductivity are self-explanatory, each working on their own scale up or down for a desired effect. The delivery method can be varied: an overall bath, an aqueous spray, swabbing, or gels, among others. Modifiers to the aqueous solutions and the delivery methods are often chelators or enzymes, an additional element that goes beyond manipulation of the pH and conductivity. The intention is to control these elements individually to treat only what is necessary, identifying the precise requirement for our treatments and introducing nothing more.

As with all treatment methodologies, testing informs the decision making for this treatment system. The manner of testing is slightly different from traditional methods and informs slightly differently as well. To start, small pellets of 5% agarose are placed on the surface of the paper, stain, and sometimes media (if it is being treated) for a number of minutes, usually between 5 and 10. The pellets are then transferred to the separate wells of the pH and conductivity meters, and readings are taken. The readings start to help inform paper conservators of the characteristics of the materials and how they might relate to each other.

There are two important things to note during this stage. First, remember that a microtreatment has been performed on the paper, stain, or media. Did the paper swell? Did the gel draw up discoloration? Was the gel too wet and now there are tide lines? These are observations that will be pieced together before the treatment is scaled up. It is also important to note that at every stage, treatments are observed both in visible and UV illumination. UV light shows how the stain and treatment are progressing and if further staining could possibly arise after the artwork leaves the studio.

Second, the interpretation of the numbers is important to understand. The readings are an approximation of the situation that is relevant to the paper, a broad indicator, but do not consider it absolute. It may help to reconsider what happened during the testing: by diffusion, material was solubilized from the paper or from the stain and was drawn up with capillary action into an agarose pellet. Surely not everything was drawn up into the gel, and surely not everything was solubilized during the testing. However, from experience, it is evident that the resulting numbers are useful in informing conservators of the similarity or disparity between the paper and the stain. In testing and interpretation, it is helpful to think about these as relationships, not absolutes.

Once the testing and micro-observations are complete, conservators can start to formulate a treatment that will modulate their intervention. Remember, the overarching goal in this methodology is to reduce evidence of intervention, to leave as little trace as possible indicating that conservators were ever there. Keeping this in mind, conservators assess their tests and the object and ask, did it do anything? If there was any change whatsoever, this is the key to treatment with subtlety. Even the most minute shift, when repeated, can result in a treatment that has little overall effect on the artwork but reduces the presence or appearance of damage.

PRACTICAL APPLICATIONS

Figures 2 and 3 are of a small graphite drawing on cream wove paper from the mid-19th century. It had a distinctive mat burn and overall discoloration, with some orange oil-like discoloration in the center of the bottom edge. In previous treatment methodology, the authors may have float or blotter washed the drawing several times with calcified water, knowing that the overall discoloration would reduce, and hoping that the mat burn would diffuse. If treatment of the mat burn were unsuccessful, then a low-percentage reducing bleach might be used, such as sodium borohydride, to diffuse the distinct line, followed by at least one more overall wash. The bleach might have also been used on the orange staining, or it might be reduced on the suction platen with alternating acid/base water, or solvents.

Instead, the authors tried to stay as light as possible, affecting change slowly and only to the point that was necessary. First, the mat burn was locally reduced and diffused around the perimeter with a chelator gel, in this case citric acid adjusted to a pH of 6.0 and suspended in an agarose gel, and followed this with an agarose gel rinse. The orange stain at the bottom was lightened with the same chelator gel and rinse. After local work, it was going to be beneficial to the paper to wash overall, as there was a significant amount of overall discoloration and the media could withstand that type of treatment. The sheet was blotter washed with adjusted water with a pH of 6.5 and a conductivity of 1 milliSiemen/cm. The blotter wash was repeated two more times and then dried.

For those who are familiar with blotter washing, it is common to have to reposition the artwork once it is on the blotter because the paper expands with moisture. When using adjusted water that is similar in conductivity to the artwork, it simply does not expand and distort as one might expect. If it is expanding less, that also means that the surface is not swelling and changing significantly. It can be inferred that since there is less overall expansion, there may also be less disruption of the media on the surface of the paper. There is still diffusion of soluble acids migrating out of the paper but with much less physical disturbance.

One of Marcel Duchamp's (1887-1968) *Fluttering Hearts*, the print in figures 4 and 5 had been exposed to significant moisture, with heavy cockling and water stains along the lower edge. In addition to overall foxing of varying degrees, the paper also had orange fingerprints in the upper left corner

Fig. 2. Before treatment. Jervis McEntee, *Flowery Tree and Pigs*, 1857.

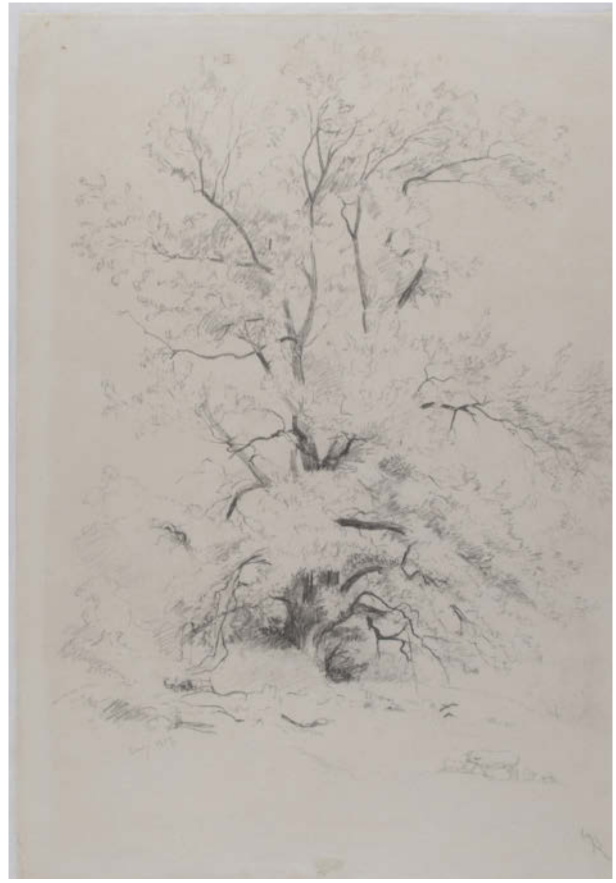


Fig. 3. After treatment. Jervis McEntee, *Flowery Tree and Pigs*, 1857.

that might be related to the acids or oils on someone's hands. Additionally, there was general darkening around the perimeter of the sheet due to its acidic housing. Because this was a screenprint on a very smooth surface-sized paper, washing was out of the question because of the likelihood that the printing ink would crack and the paper surface would be lost.

Instead, this was treated entirely with local work. The water stains along the bottom edge and the foxing spots were both reduced with a chelator gel, again citric acid at a pH of 6.0 in agarose. The fingerprints and the edge discoloration were treated with isotonic adjusted water on a cotton ball, gently swiping the damp cotton across the paper. An isotonic solution in this case was a pH of 5.5 and conductivity of 1 milliSiemen/cm. Using isotonic water allowed the cotton ball to gently glide across the surface, with no visible surface texture interruptions. If water with a different conductivity were used, such as calcified water, this technique would not work, with the cotton snagging and pilling the surface of the paper. Adjusting the conductivity of the water allowed for less swelling and therefore less wetting and penetration of the paper. After humidification and flattening, the print was significantly improved, and the image itself was never touched. Looking back to the goals for treatment of stains, the media was not affected in any way, and the majority of the original content of the paper was left intact, drawing discoloration away from the surface only where necessary.

Figures 6 and 7 show details of an Agnes Martin (1912-2004) preparatory drawing in black ink on thin, translucent paper. The delicate paper had small, irregularly shaped orange staining in the margin next to and under the ink. The testing for this piece showed that it was very easy to overclean the paper around the stain, as there was a degree of overall discoloration. An overall treatment in this case would qualify as excessive by the standards outlined in the aforementioned goals. The damage was only local and could be treated effectively by local treatment. Discoloration of Martin's papers can often be likened to patina, a characteristic that should be considered heavily before reducing with an overall treatment. Typically, the papers also respond extremely to moisture, expanding strongly, and this risks changes in the relationship between the paper and the media.

Even though pH and conductivity adjusted waters were not used in this circumstance, observing the testing to see how the agarose pellet affected the paper was instructive for designing the treatment. In the end, the stains were reduced with a chelator gel (citric acid at pH 6.0) and an agarose rinse, with 2- to 3-minute applications repeated several times, and drying in between. Quick but incremental applications

Fig. 4. Before treatment detail. Marcel Duchamp, *Fluttering Hearts*, 1961.

reduced the chance of introducing tide lines and reduced surface distortions that might have occurred if the gel were left too long. The amount of moisture ultimately introduced was so low that none of the surrounding paper or media was affected.

Much of David Hammons' (1943-) work on paper is comprised of the body print, in which the artist coats the subject of the print in an oily substance and lays it down on the support, then sprinkles pigment on the oily medium, shaking off the excess. One particular piece (not shown) is composed on black Crescent mat board with a white paper core, and the media is loose white pigment bound to the surface by the oil component. The piece sustained significant direct and

Fig. 5. After treatment, detail. Marcel Duchamp, *Fluttering Hearts*, 1961.

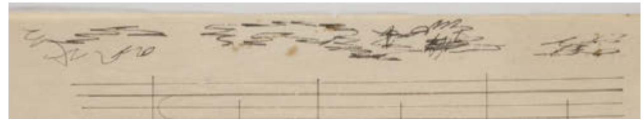


Fig. 6. Before treatment, detail. Agnes Martin, *Untitled*, 1960s.

indirect moisture, with lifting and cockled layers of board, and severe mold staining on the back. The focus of this case study, however, was a drip mark near the left edge that ran horizontally into the figure's face. Since the black paper is only a paper skin adhered to the board, and considering the difficulty of treating black paper without disturbing how light reflects off the surface, there were limited options for treatment. Fortunately, the white staining solubilized with agarose pellets, so the pellets were slowly moved along the drip to reduce the hardest of the lines, trying to diffuse the most obvious. It was important that the dampness of the gel did not lift the paper skin from the core of the board while simultaneously maintaining the surface characteristics of the paper. In a circumstance like this, even if the stain were reduced, a change incurred in the paper texture could be equally as distracting as the white haze from the damage.

In contrast, another Marcel Duchamp print, *Print of Urinal* (not shown), had been treated for a persistent stain that was likely due to exposure to liquid water. The print was on a waterleaf paper that was roughly textured, and the lower third of the print was distinctly discolored, with a tide line at the front of the discoloration visible under UV illumination. The print had been successfully treated aqueously, with staining removed; however, after several months, the stain returned. It was evident that the material that continued to change color was not fully removed, so adjusted waters and chelator gels were used in a more prescriptive manner. The goal was to use chelators to complex mineral components causing bonding of the material in question, and to affect swelling of the paper fibers with adjusted waters in an effort to evacuate as much damaging material as possible.

Because the paper swelled significantly with local moisture, an initial chelator gel of citric acid (pH 6.0) was applied only to the discoloration while the object was in a humidification chamber, rinsing with an agarose gel. Applying gels in a humid environment reduces the chance of physical distortions on reactive paper. The print was then blotter washed with an adjusted water (pH 6.6, 6 milliSiemen/cm), with local brush application of a higher pH water (pH 8.5, 6 milliSiemen/cm). After complete drying, the blotter wash was repeated and dried again. An additional chelator gel of ethylenediaminetetraacetic acid (EDTA) (pH 6.0) was applied

Fig. 7. After treatment, detail. Agnes Martin, *Untitled*, 1960s.

twice more to the discolored area, again in a humidification chamber and rinsing with an agarose gel. After the final drying, the discoloration was significantly reduced and after many months did not reappear.

One of the original intentions of this study was to compare traditional treatments to this newer system of treatment, and evaluate them against one another once they were complete. To do this, test samples were chosen that were older papers similar to what the majority of conservators might see in their practice (fig. 8). They were cut into sections, and the same stain was treated in different ways. After much trial and error, the treatments did not turn out as anticipated. The subtlety that was intended came out a bit clunky, with agarose gels causing tide lines and surface disruptions, and adjusted waters not reducing discoloration as much as expected.

In the end, the issue was probably not the techniques themselves but how they were being used. The authors' studio is accustomed to modern and contemporary art, and their refinement of these methods have been on those types of objects. These were old papers, with old stains, and it is likely that they needed different modifications to the methods being used. Recall the different factors that can be modified with this system: the pH, the conductivity, the delivery method, and modifiers. This leads to a large array of possibilities when combined with the peculiarities of the artwork, so finding the right balance can take some time. Even something as simple as changing the percentage of the agarose from 5% to 7% can have a drastic effect on the control of the treatment.

Another factor to consider is that these methods may not be efficient or effective enough for every treatment. Every once in a while, the chelator gels or the adjusted waters just do not have the ability to affect the damage in an acceptable way. Sometimes a stain needs to be flushed out with solvents on the suction platen. Sometimes they need to be decolorized by a bleach, because no amount of adjusted waters or chelator gels are adequately affecting them. Conceding this point is entirely valid if a more conservative approach proves ineffective.

CONCLUSION

This paper is not about doing away with treatments that paper conservators are used to and know to be effective. The goal has been to show that conservators now have a much wider range of possibilities for the treatment of stains and discoloration on paper, and many can be considered less invasive and more conservative than other options. Recalling Keiko Keyes quote once again, conservators are reminded that they have the responsibility to not only observe the subtleties, but also to use advancements in conservation to refine and control treatments. Adjusted waters and agarose gels allow conservators to work more fluidly on that scale of intervention. The tools can be used to treat artworks that were previously thought too problematic to touch, or to scale back a treatment technique that might feel too aggressive. Knowing the components of the treatment methods is essential to exercising control and recapturing the subtleties of paper.

Fig. 8. Sample papers for different types of treatments.

ACKNOWLEDGMENTS

We are indebted, as always, to Richard Wolbers, who developed these systems and shares them generously. We would also like to acknowledge the role of both Cleaning of Acrylic Painted Surfaces and the Modular Cleaning Program in furthering our knowledge in the ways in which these systems are employed in our field. Finally, to our colleagues in the conservation community who continue to offer insight and collaboration to further refine our treatments.

REFERENCES

Banik, G., and I. Brückle. 2011. *Paper and water: A guide for conservators*. Oxford, England: Butterworth-Heinemann.

Hughes, A., and M. Sullivan. 2016. Targeted cleaning of works on paper: Rigid polysaccharide gels and conductivity in aqueous solutions. *AIC Book and Paper Group Annual* 35: 30-41.

Keyes, K. M. 1978. The unique qualities of paper as an artifact in conservation treatment. *Paper Conservator* 3 (1): 4–8.

ADAM NOVAK
Paper Conservator
Daria K. Conservation LLC
New York, NY
adamrnovak@gmail.com

DARIA KEYNAN
Paper Conservator
Daria K. Conservation LLC
New York, NY
dariakconservation@gmail.com

The Story Not Told: The Examination and Treatment of Edward Steichen's Oochens

Edward Steichen (1879-1973) is best known as a photographer, but early in his career he was equally devoted to painting. Stylistically, his paintings related closely to his photographic output in their dark, atmospheric manner. In the early 1920s, however, Steichen began experimenting with a much bolder Modernist style that used flat planes of brightly colored geometric shapes. Steichen painted a series of 15 drawings depicting the Oochens, inhabitants of an imaginary republic, that were composed of three triangles following the Golden mean, the relationship between the extreme and mean ratio. Intended as a children's book, the Oochens were never completed or published. In 1923, Steichen had an epiphany and decided to abandon painting as a medium; he then systematically destroyed almost all of his Modernist paintings. Remarkably, the Oochens were spared and survived in his personal collection. Bequeathed to the National Gallery of Art, the Oochens varied in condition. The majority were stable, with only minor flaking, but three exhibited severe flaking and losses to the tempera paint layer. The Oochens required consolidation and an inpainting strategy that would match the matte appearance of the paint and be as reversible as possible. A technique was developed using toned microcellulose powder sprayed with an external mix airbrush, based on a process pioneered by Elissa O'Loughlin and further developed by Rebecca Pollack. Originally, the cellulose powder was used to cover foxing spots and stains or as a paper fill. In this application, the cellulose powder was toned with fluid acrylics to match the media. The cellulose and acrylic slurry was sprayed on a base coat of methyl cellulose, forming a thin, pliable, self-adhesive film. The thin sheets of inpainting material were cut to shape, positioned, and adhered in place with deionized water. The inpainting fills were easily reversed with minimal moisture and left little residue behind when removed. Steichen's working methods and process were explored. His underdrawing materials and his use of a compass were observed. Steichen often created layers of opaque colors until he achieved the desired color relationships in the drawing. When possible, these underlayers were digitally reconstructed. As little is known about Steichen's materials from this period, scientific analysis was carried out to determine the paint binder and pigments, especially those in the flaking paint.

LINDA OWEN
Associate Paper Conservator
Baltimore Museum of Art
Baltimore, MD
lowen@artbma.org

KATHRYN MORALES
Conservation Scientist
National Gallery of Art
Washington, DC
k-morales@nga.gov

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

ALAN PUGLIA AND DEBORA D. MAYER

The Challenge of Scale Revisited: Lessons Learned from Treatment and Mounting an Exhibition of 160 Illuminated Manuscripts

FOREWARD

This paper is a sequel to "The Challenge of Scale: Treatment of 160 Illuminated Manuscripts for Exhibition," as presented by Debora Mayer at AIC Toronto 2016 and published in volume 35 of the 2016 *AIC Book and Paper Group Annual*. The Challenge of Scale (Mayer and Puglia 2016) details the project to prepare more than 160 illuminated manuscripts from Harvard libraries in a two-year period for the exhibition *Beyond Words: Illuminated Manuscripts in Boston Collections.* The exhibition opened in September 2016 in three simultaneous venues. That work covered the estimating procedure used to calculate the time required to treat the manuscripts and how staffing and workflow were planned to match the scale of the project. The paper also highlighted the treatment protocol developed by the Weissman Preservation Center staff for the consolidation of friable and flaking media typical of illuminated medieval and renaissance manuscripts. The protocol detailed procedures to evaluate, treat, and document the consolidation of the manuscripts to ensure uniformity in treatment and judgment among the 10 conservators working on the project.

Although some details from the prior work (Mayer and Puglia 2016) have been summarized and included in the following, readers will find this paper more informative if they familiarize themselves with that work before proceeding.

INTRODUCTION

This paper follows the completion of the exhibition process and continues through a critical review of 16 manuscripts following the exhibition.

Exhibition preparations will be discussed briefly and include some management and organization approaches, cradle fabrication, and condition checking procedures. Installation and the strapping technique using nylon monofilament thread are discussed.

Following the exhibition, 16 manuscripts were re-examined for changes in media condition that might have occurred as a result of exhibition and retreated as needed. The pre- and post-exhibition consolidation documentation was closely compared to identify new or resurgent areas of insecure media. This paper discusses consolidation time estimates, changes incurred by the manuscripts, and efforts to evaluate and refine the treatment protocol for unstable media as developed in Harvard University's Weissman Preservation Center.

ORGANIZATION OF EXHIBITION PREPARATIONS

Organizing exhibit preparations eventually became full-time work for two Houghton library staff. The preservation librarian at Houghton Library acted as registrar for all manuscripts from Harvard libraries. This work included preparing the venue installation notebooks and documentation; coordinating all communication with conservators, registrars, and staff at Boston College McMullen Museum of Art and the Isabella Stewart Gardener Museum (ISGM); arranging for art shipping to and from the two off-site venues; and planning for installation at all three venues.

Following conservation treatment, the Houghton Library conservator organized all cradle and mount making and condition checks at Houghton Library. This work included generating all tracking spreadsheets, tags and labels for cradles, and documentation forms; preparing cradle and condition check candidates on a daily basis; performing final quality control checks; and shelving completed manuscripts and cradles by venue. Further, the Houghton Library's conservator and Houghton's conservation technician assembled all supplies and equipment needed for off-site installation.

Extensive support from Houghton Library was required, as six non-Houghton staff members were required to measure manuscripts and fabricate cradles but were unable to access Houghton Library's Aeon circulation software and were unfamiliar with Houghton Library's storage areas.

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

Poster-sized printouts of spreadsheets listing manuscripts for each venue provided a low-tech but highly effective tracking method accessible to all team members. The printed spreadsheets were reassuring since progress was clearly visible as items were checked off, and next steps were obvious at a quick glance.

CRADLES AND MOUNTS

Black mat board cradles are the preferred style in Houghton Library and were selected as the cradle of choice for the majority of volumes due to their low cost and ease of manufacture. Black mat board cradles also had the advantage of blending with the exhibition designs at all three venues. Plexiglas cradles were specified only for the largest, heaviest manuscripts where board cradles would not suffice. A local fabrication company, Altec Plastics, was contracted to manufacture 25 Plexiglas cradles.

Figure 1 shows a typical cradle along with the organizational aids used for all manuscripts. A color-coded tracking slip on the bottom of each cradle identified the manuscript, specified the exhibition venue, and included an image of the opening to be displayed. The polyethylene strap on the side reiterated the venue and included a manuscript identification number linked to case layout maps for each venue. Installation notebooks for each venue included case layouts, item identification, and installation details as needed for individual items.

A detailed specification for cradle design was prepared and made available to the two off-site exhibition venues to improve consistency. The ISGM contracted with the North Bennet Street School (NBSS) to fabricate cradles for some of the ISGM manuscripts. An NBSS student working as a summer intern at Harvard University's Graduate School of Design received hands-on training in cradle fabrication at the Houghton Library and provided continuity in style and manufacture as she worked on the NBSS team fabricating cradles.

Fig. 1. Sample black mat board cradle with color-coded label and identification strap.

CONDITION CHECKS

Condition checks were performed at four stages for all materials traveling to off-site venues: before materials left Houghton Library, on receipt at each venue, as materials were deinstalled, and on receipt back at Houghton Library. Condition notes were made on paper forms using some check boxes, simple narrative information, and color-coded pencil annotations to printed images. Digital photographs were made of particular details as needed throughout the process.

The Weissman Preservation Center staff investigated tablets and other digital methods of recording condition check information. Commercially available documentation systems were considered for benefits and drawbacks. Due to the complexity of this exhibition and its deadlines, we chose not to implement a new condition checking system for this exhibition. Following the exhibition and consolidation review process, exhibition/loan documentation systems using tablets will be reviewed and a system compatible with the Weissman Preservation Center's conservation database will be developed.

STRAPPING MATERIAL

Although traditional polyethylene strapping can be made reasonably discreet, a more minimalist look was preferred. We opted to follow the lead of other institutions and planned for a double strapping method—polyethylene straps on the leaves below the opening to provide the strength, then one, or occasionally two, strands of hair silk would be used on the leaves of the opening to minimize the visual impact of strapping.

However, the hair silk purchased for strapping purposes was found to be unsuitable. The silk thread was particularly weak and broke easily. Further, the thread had not been properly dewaxed, and it left an oily residue on any surface it contacted. Dewaxing the silk was considered, but that would not have resolved the weakness of the thread that was of concern since addressing any thread failures at the two off-site venues would have been difficult and time consuming.

The lesson learned in finalizing the strapping technique was to be cautious when acquiring new materials, even when recommended by colleagues. The quality of supplies changes over time, sometimes rapidly. Fortunately, a suitable replacement was found on short notice.

Instead of hair silk, light-weight quilter's thread was used. Five different varieties of thread were compared on black mat

Fig. 2. Manuscript held open with nylon monofilament. Arrows point to thread locations.

board and on sample manuscripts in a variety of lighting situations. Wonder Invisible Thread, .004 Nylon Monofilament, was selected as the preferred strapping material. It was significantly stronger than the silk, had a slight stretch that allowed easy adjustment of the tension across manuscript pages, and had such a minimal visual impact as to be virtually invisible under exhibition lighting (fig. 2). We believe that the monofilament is superior to hair silk, and it is now being used as strapping material for in-house exhibitions.

INSTALLATION AND STRAPPING

Installation was carefully coordinated with teams of 8 to 10 staff working at the non-Houghton venues. The registrar was responsible for removing all materials from transport crates, matching manuscripts to their corresponding condition reports, and identifying case locations. Manuscripts were delivered to individual conservators to complete the required "as received" condition check. As sufficient condition checks were completed, two-person teams formed to begin strapping and keep work moving smoothly. As required, one staff person either worked on a strapping team or assisted the registrar by matching cradles to manuscripts and then delivering strapped items to their case locations.

Working in teams of two for installation strapping was found to be the most effective approach. Passing poly straps and nylon thread through the cradles between two people was efficient and safest for the manuscripts. One person could adjust and position straps and threads safely while the other held the manuscript open. While one person finalized a strap or completed a knot, the other could prepare the next strap, producing a very efficient workflow.

The installation approach used was very efficient and met tight time windows at the off-site venues, resulting in 97 manuscripts, including two 10- to 20-ft. scrolls, being installed at Boston College's McMullen Museum of Art in less than three full days.

PRE-EXHIBITION TREATMENT TIME ESTIMATES

Because of the short time frame and scale of the project, it was not possible to consolidate all illuminations in every manuscript. In consultation with other institutions, we adopted a policy to examine and treat as necessary only the illuminations within a 20-leaf spread of 10 leaves before and after the display opening. Illuminations on the first leaves were also included, as these are the pages that receive the most frequent, often excessive, handling.

The time estimate for media consolidation, using three minutes per square centimeter of illumination, was 2800 hours. Oversize manuscripts, structural repairs, documentation, and fabricating or modifying housings were estimated to require an additional 2200 hours. Binding and structural repairs focused on issues that would impact handling during consolidation and travel to off-site venues, and allow the manuscripts to remain open for the exhibition, which was expected to last three to four months.

Combined, an estimated 5000 hours of conservation treatment time were required to prepare all materials for exhibition, and 5000 hours over two years correlated to roughly three full-time conservators dedicated solely to this project. Cradles and mounts, condition checks, and installation were not included in this estimate.

CONSERVATION TREATMENT TIME ACTUALS

Out of a total of 160 manuscripts, 104 were transferred to the Weissman Preservation Center for conservation. Initial treatment estimates reflected a worst-case scenario, and many treatments turned out to be more modest than expected. Actual treatment time totaled 4397 hours, which was comfortably below 5000 hours.

Beyond conservation treatment, 1741 hours of conservation time were required for fabricating cradles, performing condition checks, and installing and deinstalling the Harvard materials. The carefully coordinated team approach described by Debora Mayer was equally necessary for this work. As consolidation efforts tapered off, team members shifted focus to other exhibition tasks, and the pace of work actually increased over the last six months as additional staff were involved.

CONSOLIDATION PROTOCOL REVIEW

Completing the installation of the Harvard Library's portion of the *Beyond Words* exhibition allowed the conservation team to take a step back. Debrief meetings were held to identify lessons learned throughout the process. Exhibition preparations and installation had gone well, and we were confident that the consolidation protocol was a valuable tool, but there is always room for improvement.

In addition to the debrief discussions, the Weissman Preservation Center had an opportunity to systematically review a large body of our conservation work. The conservation team had been pleased with the results as manuscripts were completed in the conservation lab. However, without reviewing manuscripts following the exhibition, there was no way to know if we had successfully stabilized the manuscripts against the rigors of exhibition and the associated handling. Following conservation but before the exhibition, many of the manuscripts had been fully or partially imaged for the catalog, reviewed multiple times by curators and researchers developing exhibit catalog entries, measured and fitted for cradles, and installed and eventually deinstalled. Use of some of the manuscripts by patrons and Harvard classes continued during the exhibition preparation period, further increasing handling.

Fig. 3. The microscopy station as seen from above, including tools, consolidation supplies, the computer monitor displaying the during treatment image of the illumination, and the notebook of treatment notes and records.

CONSOLIDATION PROTOCOL

Key principles of the consolidation protocol included the following (Mayer and Puglia 2016):

» *Consistent procedures.* An example is the use of the same magnification (15x) and tools to judge stability/friability of media.

» *Uniform judgment parameters*. The decision to treat is based on the actual detection of loose or friable media. Consolidation is not considered a proactive measure. Media that is cracked or looks horrible but tests stable is not treated.

» *Quality control.* One conservator treats a given illumination and a second conservator reviews the work to ensure treatment success. In this way, we ensure that we do not miss areas, the consolidation is effective, and there is no change in media appearance.

» *Open and frequent communication*. Best practices are achieved through collective and collaborative understanding, which requires discussion, being open-minded, sharing observations, and letting go of ego.

SUMMARY OF CONSOLIDATION TREATMENT PROCEDURE

While looking through the microscope, the conservator used an endontic paper point, instead of a brush, to lightly touch the media to detect media insecurity. Chips of media were lightly touched to watch for movement and to see if a shadow line increased or decreased. Powdery or friable media was detected when small particles moved as the paper point lightly touched and stroked the surface (fig. 3).

Flaking and friable media were consolidated with dilute gelatin, typically applied with a small brush at the edge of chips or along crack lines in the paint and over granular surfaces. In most cases, bovine gelatin (Acros Organics, type B, ~100 bloom) at a 1.5% w/v solution in deionized water was used. In certain instances, high molecular weight (HMW) fish gelatin (Norland Products) was used when stronger adhesion, better flow, or higher tack at greater dilution was warranted.

A digital image of the illumination was displayed on a computer monitor and was marked up using Photoshop to delineate the areas of consolidation treatment. At the same time, in the treatment notebook, a black and white printout of the image was also marked up to record treatment locations and progress across the page, and served as a place to share notes with all team members.

Once an illumination, or section of illumination, was completed, it was allowed to dry at least 12 hours. The same illumination was then reviewed and checked by a different conservator to ensure that no unstable areas were missed and that treatment was successful. Treatment was considered complete when two different conservators had reviewed the same illumination and confirmed the media was stable (Mayer and Puglia 2016).

ORGANIZATIONAL CONCERNS

Discussions during debrief meetings identified two areas where key principles had not been followed as closely as expected throughout the treatment phase of the project. Uniformity of treatment had been inconsistent in small ways due to a particular breakdown in open communications.

To meet the demanding exhibition schedule, the consolidation work flow required 10 conservators, divided into two consolidation teams of 5 conservators, with each team working 25 to 30 hours each week for two years. The procedures and communication within each team had been excellent. Documentation notebooks at both microscope stations had included copies of the treatment proposals, articles and research relating to the manuscripts, and printed photos of all leaves to be treated. Page by page, media issues and treatment notes were recorded in these notebooks. Discussions between conservators within each team had been frequent, as treatment was handed off from team member to team member after each 2- to 3-hour shift. Work was consistent, uniform, and of good quality. However, during debrief discussions, it was discovered that communication and procedures *between* the two teams had drifted apart slightly over time.

Each team had been faced with a unique combination of manuscripts with their very different support pages, media, bindings, and so on. As each team addressed their unique circumstances, they had created their own small variations on treatment techniques and handling. In and of themselves, none of these variations were of great consequence; however, it was a surprise that we had not anticipated. In some cases, the changes and efficiencies might have been helpful across both teams, such as refinement on how and when alcohol was used with certain pigments. The pressure of maintaining production had created extremely efficient teams but had narrowed our focus to the team level, and communication between the teams had not been as open as expected.

This is an embarrassment of riches since few conservation labs are large enough to field two consolidation teams of five conservators each. Realistically, the Weissman Preservation Center may never need two teams again, but if it does, lesson learned: maintaining open communications under pressure is a challenge, and it needs to be between teams as well as within teams.

PROTOCOL AND CONSOLIDATION REVIEW POST-EXHIBITION

Judging the effectiveness of our consolidation work required returning to a selection of manuscripts, re-examining the same range of pages, and retreating them if necessary. This was a much more significant undertaking than a few debrief meetings. An initial estimate for the review project was 630 hours—a substantial time investment considering that the exhibition had already required more than 6000 hours. The additional conservation time for the review project was approved, and thus two consolidation teams were reformed and the review work moved forward.

Drawing from lists of manuscripts treated and by taking suggestions from the teams, 16 manuscripts were selected for review—approximately 15% of the 104 treated manuscripts. The selection was fairly representative of the whole and reflected the range of media conditions and the degree of treatment that had been required during exhibition preparations.

We chose to perform the review as a blind study as much as was reasonable. We hoped to make our observations and treatment decisions as objectively as possible but did not want to repeat any unsuccessful treatment approaches. Team leaders and the project coordinator reviewed the pre-exhibition treatments to identify adhesive choices and other key areas of concern, then relayed that information to the consolidation teams. Team members were certain to remember particular manuscripts but would not preview the photographic or written documentation from the pre-exhibition treatments.

The blind study was very effective. Although it was very tempting to peek at the documentation, all team members supported the blind study approach. In a few cases, specific questions were raised and the team in question asked a member of the *other* team to review the previous treatment file to locate required information. Only a few problematic items required a more systematic review of the earlier documentation.

RESULT

Approximately two-thirds of the manuscripts reviewed, 11 of 16, required only minor additional consolidation treatment in small spots in isolated areas. For these manuscripts, treatment times during the review were significantly reduced from the first round of consolidation, down to just over two minutes per square centimeter. Treatment was approaching the minimum time required to simply check all media for stability and consolidating only occasional small areas. The sound condition of the illuminations in these 11 manuscripts indicates that the consolidation protocol was successful in stabilizing these illuminations against the rigors of exhibition.

Further, the review of these 11 manuscripts also reinforced the base time estimates for consolidation using our protocol. The estimate of three minutes per square centimeter with time increasing for more complex manuscripts seems to be an accurate time for estimating consolidation projects overall.

The remaining five manuscripts reviewed had been substantially stabilized by the pre-exhibition treatment but were found to have more media instability than was ideal following exhibition. These five manuscripts were not a surprise, as they were among the most challenging manuscripts treated prior to the exhibition.

Overall, the results are very positive for the success of the consolidation protocol. As noted earlier, we had specifically wanted to know how the least stable materials had fared throughout the exhibition process. The selection had been weighted toward some of the most problematic and severely damaged items yielding a higher percentage of challenging manuscripts in our sample set than was present in the entire group. The percentage of manuscripts in the exhibition with minor to moderate condition issues was considerably higher than two-thirds. Therefore, we feel confident that the majority of the manuscripts remained relatively stable throughout the exhibition process. Further, even the worst manuscripts had been significantly stabilized by the pre-exhibition treatment.

PHOTODOCUMENTATION PROCESS

Working in Photoshop, all areas treated with a consolidation adhesive were marked in a fluorescent or other bright color. For the review, returning to the pre-exhibition treatment images would not have been a blind study. To be able to accurately compare before and after exhibition treatments, and to reduce handling of the manuscripts, the unaltered before-treatment images from the pre-exhibition treatments were used for the review.

Composite images were created by combining the marked up pre- and post-exhibition treatment images, allowing the two treatment campaigns to be viewed together. Areas of new instability were clearly visible and resurgent instability was easily identified where pre- and post-exhibition treatments overlapped.

Please note that the printed version of this paper is accompanied by black and white illustrations. These printed images will not allow accurate interpretation of the treatment documentation presented in the following. The PDF/web version of the paper includes the color illustrations necessary to properly interpret the details comparing pre- and post-exhibition media consolidation.

CASE STUDIES

Case Study 1: Ms Typ 443.1

Figure 4 shows an example of a manuscript page requiring modest consolidation pre-exhibition that required no treatment during post-exhibition review. This is an example of a generally stable manuscript leaf, representative of many full manuscripts as well as individual leaves within problematic manuscripts, which remained stable throughout the exhibition process, including imaging and occasional researcher use.

Fig. 4. An example of a minor treatment pre-exhibition requiring no treatment post-exhibition. Book of Hours and Missal, Ms Typ 443.1, Houghton Library, Harvard University.

Case Study 2: Ms Typ 464

Figure 5 shows an example of a more involved pre-exhibition treatment that required only minor stabilization treatment post-exhibition. This is one of the manuscripts where the reduced treatment time indicates an overall improvement in the manuscript's condition and that the illuminations remained stable throughout the exhibition process.

In reviewing Ms Typ 443.1 and Ms Typ 464, one with moderately significant media instability before exhibition, it was found that even moderate media issues were successfully stabilized using the Weissman Preservation Center's consolidation protocol. We are confident that many of the manuscripts withstood the rigors of the exhibition and associated handling quite well.

Case Study 3: Ms Lat 267

Figure 6 shows a detail image of the upper margin of one leaf. The media included significant areas of exposed soft, easily abraded off-white ground that was crumbling in spots. This

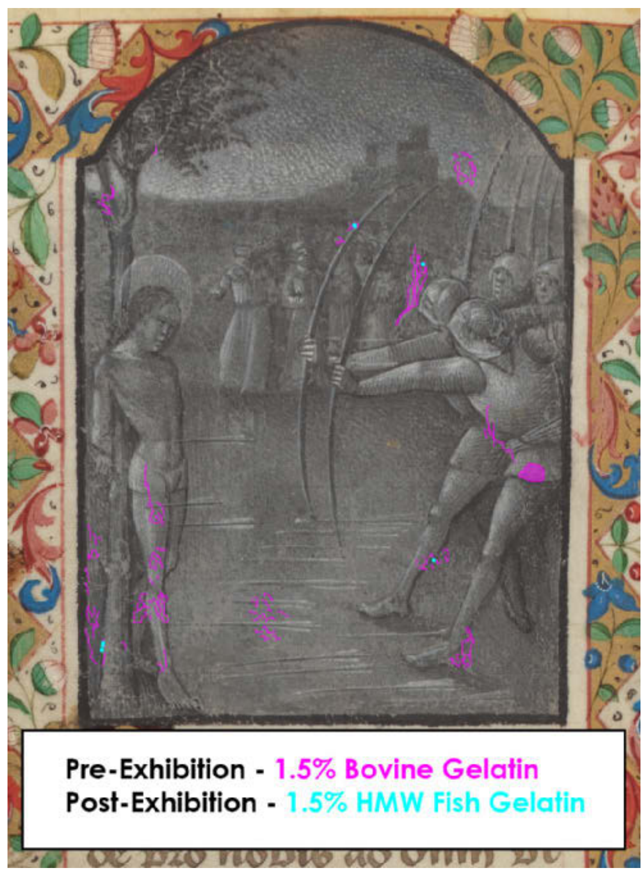


Fig. 5. An example of moderate treatment pre-exhibition requiring only minor treatment post-exhibition. Book of Hours, Ms Typ 464, Houghton Library, Harvard University.

Fig. 6. Detail image of an illumination with severe media instability. Pre-exhibition treatment was moderately successful, but new and resurgent instability was found post-exhibition. Treatment was halted pending future conservation to address the complete manuscript. Breviary, Ms Lat 267, Houghton Library, Harvard University.

manuscript received fairly extensive treatment prior to the exhibition, marked in magenta.

The full manuscript contained 423 leaves; however, stabilization for the exhibition had been limited to only 21 leaves, 10 on either side of the opening, plus the frontispiece. Within those 21 leaves, stabilization had targeted only the most unstable areas of media. The limited consolidation approach to this manuscript was considered only because it was to be exhibited at Harvard's Houghton Library and not subject to the rigors of transport.

Consolidation had been generally effective, but some previously treated areas were again friable and crumbling despite the prior consolidation. Surrounding untreated areas, which would have tested as being reasonably stable before exhibition, had areas of more active media loss following exhibition.

A review of the 21 leaves treated for the exhibition was of minimal benefit to the manuscript, and continued testing would not have added significantly to the knowledge gained from the review. The manuscript required a systematic treatment of the complete manuscript. A few small test treatments using variations in adhesive and alcohol application, shown in cyan and green, were performed to guide future work. Ms Lat 267 was returned to Houghton Library with a strong recommendation that handling and use of the manuscript be restricted until a full treatment could be completed.

Case Study 4: Ms Typ 207

Figure 7 shows a detail of one leaf in a manuscript of only 29 leaves. The locations of pre-exhibition consolidation are shown in magenta, and post-exhibition consolidation is shown in green. Consolidation during the post-exhibition review was generally applied in previously untreated areas. This indicates that the earlier consolidation had been effective where it had been applied. This raises the possibility that the pre-exhibition media testing had not been thorough enough and these areas had been missed. However, the protocol includes extensive cross-checking procedures by multiple conservators, so it is unlikely that this was the case.

Fig. 7. Detail image of an illumination with moderate media instability pre-exhibition with moderate new media instability identified post-exhibition. *Les diz moraulx des philosophes*, Ms Typ 207, Houghton Library, Harvard University.

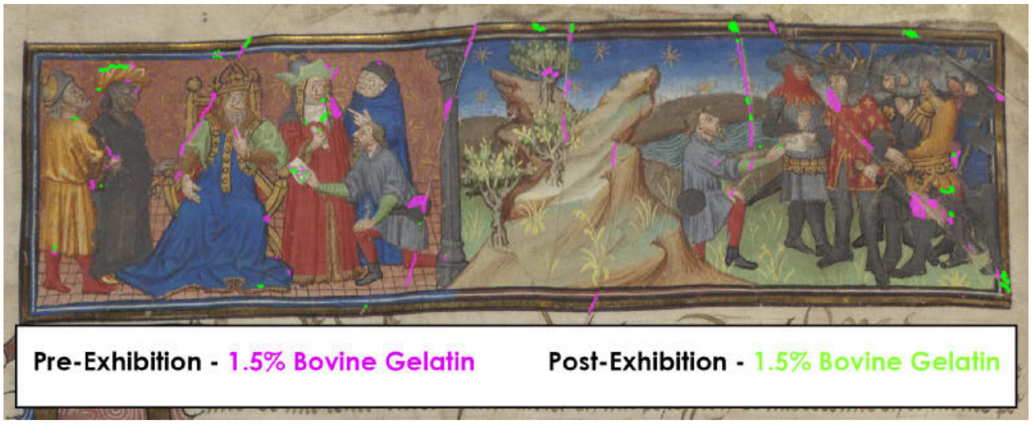


Fig. 8. Detail image of a second illumination from Ms Typ 207. As in figure 7, moderate new media instability was found post-exhibition. Consolidation is more clearly associated with creases and other areas where the leaf flexes during handling. *Les diz moraulx des philosophes*, Ms Typ 207, Houghton Library, Harvard University."

Figure 8 shows a detail from a second leaf from Ms Typ 207. As in figure 7, the new consolidation is concentrated in previously untreated areas. However, in figure 8, it is more obvious that most of the treatment follows a series of creases in the leaf.

In addition to the creases, Ms Typ 207 also had significant cockling in the gutter that caused or was made worse by an inappropriate, modern rebinding. These issues had been very apparent before the exhibition. No matter how carefully the volume was handled, turning the leaves produced cringe-worthy "snap, crackle, pop" sounds as concave and convex areas flexed. The creased areas were also at higher risk from page movement, as these lines flexed more easily than other areas of the leaves.

In reviewing this manuscript, our judgment was that use and careful handling is the primary condition issue for this media. Even the most careful handing in the conservation lab was suspect.

The importance of careful use and handling is not a new concern, but manuscripts like this highlight the significance. Even the most careful, effective stabilization treatment is not proof against handling, no matter how careful. Further, even manuscripts that have been fully conserved cannot be put entirely out of mind, as even the best conservation treatments may fail over time, particularly when stressed by handling.

Unfortunately, limiting access to manuscripts can be a difficult decision. Restricted access must be carefully considered and weighed against Harvard University's teaching mission. Use by patrons, faculty, and students is considered the primary goal of our institution.

Although this is not a change to the consolidation protocol, Weissman Preservation Center staff will continue to work closely with curators and access services staff to review handling and use guidelines for manuscript collections.

Case Study 5: Ms Typ 252

The binding on this manuscript was extremely tight, and opening beyond 100° was not advisable. Much like Ms Typ 207 in Case Study 4, cockling in the gutter posed a risk for media. Despite these issues, only three leaves in the entire manuscript showed severe media damage and a few other leaves had moderate damage.

Figure 9 shows one of the most severely damaged pages. Marked in magenta are significant losses where the loss edges were treated with bovine gelatin prior to exhibition. However, even at the highest concentration we were comfortable using, the bovine gelatin was not effective at stabilizing the media. Marked in yellow around the perimeters of the losses, many of the same areas were then successfully stabilized using HMW fish gelatin. The HMW fish gelatin was selected for its higher tack at lower concentrations, improved flow during application, and ease of preparation. HMW fish gelatin is

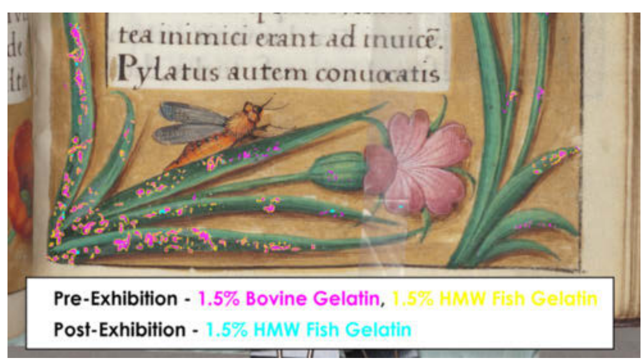


Fig. 9. Detail image of an illumination with significant losses and severe media instability. Pre-exhibition treatment started with bovine gelatin but moved to HMW fish gelatin. Moderate media instability was found post-exhibition and was treated with HMW fish gelatin. Gospel readings for Holy Week, Ms Typ 252, Houghton Library, Harvard University.

Fig. 10. A second example of a severely damage illumination from Ms Typ 252, also found to have moderate media instability post-exhibition. Gospel readings for Holy Week, Ms Typ 252, Houghton Library, Harvard University.

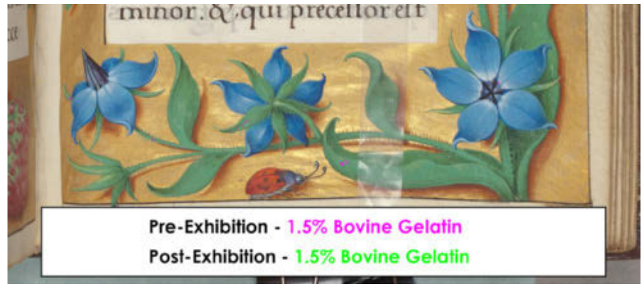


Fig. 11. Detail image of an illumination from Ms Typ 252 with the same color palette as figure 10 but in excellent condition. Comparison to figures 9 and 10 reveal a second artist, whose work was less susceptible to media instability. Gospel readings for Holy Week, Ms Typ 252, Houghton Library, Harvard University.

being investigated at the Weissman Preservation Center as an alternative to isinglass for consolidation and is currently being used as the preferred adhesive for parchment repair.

The post-exhibition review treatment again used HMW fish gelatin, which is marked in cyan. The review treatment was a mixture of retreatment of some previously stabilized areas plus treatment of some new areas following the exhibition. Although treatment was required, the amount of treatment during the post-exhibition review did not seem excessive given the condition of the page and the handling required for the exhibition process.

Figure 10 shows a second page with the same severe deterioration pattern. In this case, the issue with bovine gelatin was identified early in this page's treatment and fish gelatin was the primary adhesive, so fewer areas of magenta are marked. During the post-exhibition review, this page required a more significant amount of treatment, shown in cyan.

The amount of new and retreatment did not represent a major failure of the protocol but was sufficient to raise a concern. This manuscript and page generated a very lively discussion, but we were unable to identify any particular aspect of the protocol that would be considered a failure in this situation. However, in examining the manuscript more closely, one factor that appears to be common to the most damaged leaves is the artist who executed the illuminations. Figure 11 presents one of the leaves with the same color palette but is in excellent condition. The leaves appear similar, but closer examination reveals differences in the media of the gold backgrounds, the fineness of pigment preparation, and the skill of execution. Approximately one-third of the manuscript appears to have been illuminated by one particular artist whose work seems more prone to instability and required the majority of treatment in the manuscript.

STABILITY FACTORS

In reviewing the five problem manuscripts, we were unable to identify any major flaw in the consolidation protocol that might lead to the problems observed. Instead, the manuscripts all presented inherent stability issues that would have been difficult to address in the best of circumstances. Addressing these issues had been complicated by the deadlines imposed by the exhibition schedule. Another complicating factor was the extensive handing for the exhibition, as well as the often frequent, heavy use in a research library environment.

The most challenging manuscripts treated, both before and after exhibition, posed one common question that was difficult to answer: when should we stop the treatment? During treatment, it was obvious that the worst manuscripts had been significantly improved, but they were still not as stable as we would have liked. Continuing treatment was sometimes accompanied by a sense of diminishing returns. In other cases, there was a concern that handling in the course of treatment might be causing media instability at the same time other media was being stabilized.

PROTOCOL ADJUSTMENTS

After consideration, it was decided that the Weissman Preservation Center's consolidation protocol was sound, and only minor adjustments and some elaboration was needed to address issues found during the review process.

One general principle required further emphasis—open communication. Even small changes and ideas can be of benefit to a larger group, and care must be taken to be certain that such information is communicated as widely as possible within the teams and, of equal importance, between teams. Consolidation treatments will continue in the Weissman Preservation Center, and observations and developments in technique will be discussed within the consolidation team(s) and recorded in the documentation notebook or protocol to ensure communication to all.

The issue of diminishing returns and criteria for determining when to cease treatment will be considered. Quantifying when to step back will be a challenge, but there is a point where further intervention is of limited benefit and may be even be harmful.

Common factors affecting media stability will be identified in the protocol as red flags for attention. Approaches and treatment techniques that have been found helpful in such situations will be included. Particular areas for consideration are gutter cockling, ceases, glazes, and overpainting and restoration.

Adhesive selection to suite particular situations also requires further elaboration in the protocol. It is hoped that we will be able to identify the most appropriate adhesive sooner in the consolidation process. Although bovine gelatin was the preferred adhesive for most consolidation work, the HMW fish gelatin was more effective for some challenging media.

FUTURE RESEARCH

Selecting adhesives for consolidation is a subject that requires more investigation and research. Even common consolidation adhesives, such as bovine gelatin, are not well understood, particularly when one considers the variety of grades that are available, such as photo, lab, and pharmaceutical grades, each with their own physical, chemical, and working characteristics that might affect media. Future research will involve working with a conservation scientist to pursue materials testing and potentially accelerated aging. The goal will be to develop a better understanding of the range of adhesives available for consolidation and how they interact with some of the most beautiful but fragile objects in our care.

ACKNOWLEDGMENTS

We would like to thank the conservators who contributed to the post-exhibition review project and refinement of the Weissman consolidation protocol and participated in exhibition installation efforts: Catherine Badot-Costello, Katherine Beaty, Irina Gorstein, Amanda Hegarty, Laura Larkin, Kelli Piotrowski, and Christopher Sokolowski. We also wish to thank all staff who participated in exhibition preparation and installation: Livy Bailin, Susi Barbarossa, Kathryn Kenney, Carie McGinnis, Natalie Naor, and Karen Walter. We express our gratitude to curators Hope Mayo and William Stoneman for partnering with the Weissman Preservation Center conservators in the development of the protocol and for permission to use images of the manuscripts. We are very appreciative of the Weissman Preservation Center and Harvard Library for their generous support of this project.

REFERENCE

Mayer, D. D., and A. Puglia. 2016. The challenge of scale: Treatment of 160 illuminated manuscripts for exhibition. *AIC Book and Paper Group Annual* 35: 61-69.

SOURCES OF MATERIALS

Strapping thread:
Wonder Invisible Thread, .004 Nylon Monofilament
YLI Company
Locally sourced, widely available

Paper points:
Kerr Endodontics Absorbent Points, XX-Fine (16215)
Darby Dental
https://www.darbydental.com/scripts/ProdPage.aspx?grp=8540198

Adhesives:
Acros, Gelatin type B (#61225-5000)
VWR Scientific
https://us.vwr.com/store/product/18604377/gelatin-type-b-laboratory-grade

Norland High Molecular Weight (HMW) Fish Gelatin
Norland Products
https://www.norlandprod.com/fishgel/himol.html

ALAN PUGLIA
Senior Rare Book Conservator
Weissman Preservation Center, Harvard University
Cambridge, MA
alan_puglia@harvard.edu

DEBORA D. MAYER
Helen H. Glaser Conservator
Weissman Preservation Center, Harvard University
Cambridge, MA
debora_mayer@harvard.edu

SAMANTHA SHEESLEY

Sidewalks, Circles, and Stars: Reviving the Legacy of Sari Dienes

INTRODUCTION

Art conservators are often instrumental in reviving the names and legacies of long-forgotten artists. This paper reflects upon the restoration of Sari Dienes (1898-1992) as an influential 20th century artist and her path to the Virginia Museum of Fine Arts (VMFA) by way of the paper conservation department.

Sari Dienes was always well connected. Born into an upper-class Hungarian family, she married mathematician and poet Paul Dienes, to whom she dedicated her full attention. Years later, she reclaimed her life, trained as an artist in Paris, and worked in London. In 1939, she traveled to the United States for a short visit but was prevented from returning home by the outbreak of World War II (Martin 1991). Before long, she had established herself as an artist, teacher, and Zen Buddhist in New York City, countering abstract expressionism with images of found objects such as manhole covers and subway grates. She created large-scale rubbings, some more than 12 ft. in length, with black printing ink and rolls of a medical material called *Webril*, which appealed to her because of its affordability, strength, sensitivity to detail, and variability in size (Hedden 1958). Jasper Johns, who assisted her with the handling of these large prints, recalled her uninhibited nature as she unrolled the Webril in New York's streets during the early morning hours to capture the textures of the city with her inked brayer (Zeller 2008).

Dienes' New York City connections came to include other renowned artists such as John Cage, Ray Johnson, Jasper Johns, and Robert Rauschenberg. Having spent considerable time in her company, Johns and Rauschenberg were deeply inspired by Dienes and named her as a principal influence (Zeller 2008). Yet despite her impact, museums did not invest in Dienes' work because she was a woman working outside the prevailing, male-dominated style of abstract expressionism.

It was not until 1979 that Rip Hayman and Barbara Pollitt, friends of Dienes who had recognized her significance, conceived of the Sari Dienes Foundation as a way to preserve her legacy. After working closely with Sari to catalog her collection and gather pertinent information, they used a barn in Pomona, New York, to store her rubbings and other works of art, works in progress, materials, and archives. Artists themselves, Hayman and Pollitt could not afford conservation-quality housing materials or HVAC systems, and the uninsulated barn offered little sanctuary from environmental fluctuations and pests. Consequently, despite her friends' best intentions, many of Dienes' most important pieces have deteriorated and become too fragile to be considered for acquisition or exhibition by many institutions.

ACQUISITION

Nevertheless, the VMFA recently acquired two large rubbings by Sari Dienes: *Marcy* and *Esco*. *Marcy*, one of Dienes' most iconic pieces, appears in photographs of the Bonwit Teller Department Store window installations along with one of Johns' first flag paintings and one of Rauschenberg's first combines (fig. 1). Sadly, both *Marcy* and *Esco* had suffered numerous condition problems rendering them unfit for display. The delicate Webril supports were creased and torn, and numerous spots, stains, and accretions were scattered throughout the prints. A lack of glazing, the use of corrosive staples and acidic hardboard backings, flood exposure, and environmental fluctuations all contributed to the deterioration.

These seminal pieces were not acquired by the VMFA in spite of their condition, but because the museum hoped to right certain wrongs of time. The VMFA Board of Trustees considered the contextual significance provided by Sarah Eckhardt, VMFA associate curator of modern and contemporary art; the report on the objects' condition and treatment needs; the availability of conservation resources; and the potential reward of treatment by Samantha Sheesley, VMFA paper conservator. The decision to acquire Dienes' work was unanimous.

CONSERVATION TREATMENT

The novelty, scale, translucency, and fragility of the objects prompted a joint investigation and demanded innovation

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

Fig. 1. Street rubbings by Sari Dienes installed in Bonwit Teller Department Store. Courtesy of the Sari Dienes Foundation.

throughout the project. Samantha Sheesley, Sarah Eckhardt, and Barbara Pollitt, curator of the Sari Dienes Foundation, collaborated to identify key questions surrounding the artist's work. The goal was to better understand Dienes' materials and techniques through analysis of the objects and contextual clues found in the archives. The pooled information guided stabilization and compensation efforts culminating in the display of objects previously thought to be unsalvageable.

Efforts are ongoing to identify the fibers comprising the Webril supports. At the same time, Pollitt provided Webril samples that were aged naturally under the same conditions as the artwork. These samples were key to the identification of a treatment that was both safe and effective for *Marcy* (fig. 2). Multiple materials and techniques were tested, and the following treatment was employed to physically and chemically stabilize the primary support and reintegrate damages to unify the print visually:

- » A large tray, approximately 4 × 7 ft., was constructed from polyester film for washing.
- » Several pieces of thin blotter were cut from a roll, measuring approximately 3½ × 6½ ft., and layered in the polyester tray. The use of an oversized blotter eliminated the need to butt smaller blotters together and facilitated even washing overall.
- » The blotters were sprayed with calcium-enriched deionized water, pH 8.0, and then thoroughly saturated.
- » Particulate debris and surface dirt was reduced from the print with a soft brush.
- » The print was sandwiched between two pieces of nonwoven polyester, cut slightly larger than the print.
- » The print was lightly sprayed overall to relax the support in preparation for washing.
- » The humidified print was carefully positioned onto the wet blotters while sandwiched between nonwoven polyester (fig. 3) and gently brushed into contact using a mizubake brush.
- » Excess moisture and discoloration were carefully blotted from the surface of the wet print through the polyester web (fig. 4).
- » The underlying blotters were discarded and refreshed several times until discoloration ceased to wick from the primary support.
- » After blotter washing, the print was positioned on a table to air-dry between the pieces of nonwoven polyester. The edges of the nonwoven polyester were restrained with acrylic blocks to prevent planar distortions from forming in the primary support.
- » Once the print dried, it was turned over to reveal the verso. Tears were mended and small losses were bridged with narrow, torn strips of Hanji 1101 and 4% methyl cellulose A4C (figs. 5, 6).
- » Hanji 1301 was toned with Golden fluid acrylic paints to match the tone of the Webril. Inserts were cut from the toned paper to fill losses in the primary support. The inserts were adhered into areas of loss with methyl cellulose, reinforced on the verso with strips of Hanji 1101 (fig. 7).
- » The inserts were further toned from the recto with Rexel Derwent pastel pencils to compensate losses in the design (figs. 8, 9).

The print was rolled onto an alkaline-buffered paper tube for temporary storage purposes. To house and frame the print, 3-in. Hanji 1101 hinges will be attached along the perimeter of the support at regular intervals with 4% methyl cellulose A4C. The print will be positioned and attached to a rigid, alkaline, paper honeycomb panel by wrapping the hinges around the panel and adhering them to the verso. Acrylic spacers will be wrapped with acrylic-toned, alkaline-buffered paper. The spacers will be positioned between the object and a piece of Tru Vue Optium glazing. The mounted and glazed print will be fit into a new, custom-made frame. Because the VMFA retains *Marcy*'s original frame, the new frame can be made to look similar in appearance to the original.

Esco (fig. 10) differs from *Marcy* significantly despite the fact that both are rubbings of manhole covers made by Dienes in New York around 1953. *Esco* is comprised of two separate rubbings of two different manhole covers, executed in two different colors on two separate pieces of Webril, one of which

Fig. 2. Sari Dienes, *Marcy*, 1953, black ink on Webril, 181.29 × 90.17 cm, 2016.227, before treatment.

Fig. 3. Washing *Marcy* in an oversized polyester tray on blotters saturated with calcium-enriched deionized water.

Fig. 4. Blotting excess moisture from *Marcy* while washing.

has a thin layer of gauze, and both of which are adhered to a single secondary cloth support. The secondary cloth is a linen lining fabric coated on one side with a thermoplastic adhesive. Dienes used a household iron to activate the adhesive and adhere the Webril. This mounting system was used by Dienes for numerous prints in her studio. For this reason,

Fig. 5. Realigning tears along the edges of *Marcy*.

Fig. 6. Mending *Marcy* with Hanji 1101 and 4% methyl cellulose A4C.

the mount is considered original to the object and should not be removed, despite treatment limitations imposed by the secondary support. Fortunately, Pollitt provided samples of the secondary support material for testing purposes. Once the materials are identified and treatment options are tested, a treatment strategy will be established for *Esco*.

RECONSTRUCTION

The material samples provided by Pollitt and the Sari Dienes Foundation served multiple purposes during this technical investigation. In addition to pretreatment tests, some of the Webril was used to demonstrate Dienes' printing process (fig. 11). Rubbings of manhole covers were made by Sheesley in Richmond with black printing ink and a soft brayer, similar to those used by Dienes. The rubbings were made on both

Fig. 7. Inserts made from acrylic toned Hanji 1301 to fill losses in Webril.

Fig. 8. Inpainting losses to design with pastel pencils on fills made from toned Hanji 1301.

Fig. 9. *Marcy*, after treatment.

Fig. 10. Sari Dienes, *Esco*, 1953, black and red inks on Webril with gauze mounted overall to lining cloth, 106.36 x 238.13 cm, 2016.211, before treatment.

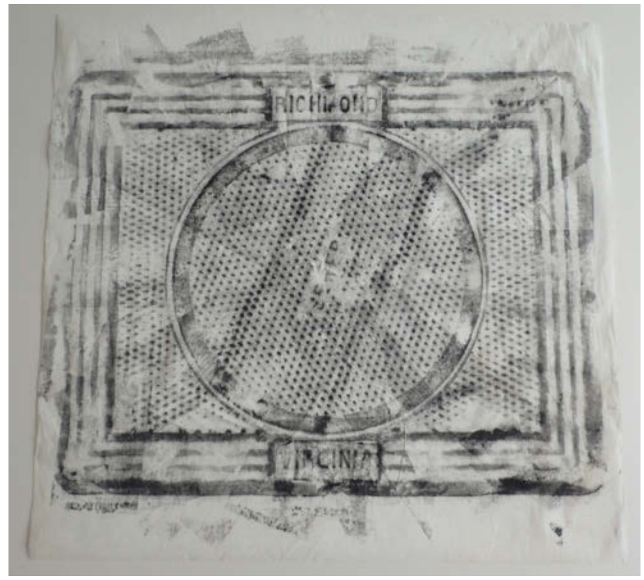


Fig. 12. Rubbing of manhole cover by Sheesley on Webril.

Webril and paper to illustrate the difference in image quality based upon the different supports (figs. 12, 13).

After the rubbings of manhole covers were made, questions arose regarding the handling of such large, fragile, wet prints while navigating city streets. How far did Dienes travel with her oversized wet prints? Did she make rubbings of manhole covers in close proximity to one another? Did she make her prints over the course of multiple sessions? A trip to New York City provided the opportunity for a scavenger hunt of sorts. Sheesley scoured the streets near Dienes' studio and the Parsons School of Design, where she taught, in search of familiar manhole covers. Sheesley's findings suggest that Dienes did not make prints from neighboring manhole covers but traveled significant distances from one locale to the next in search of subject matter.

CONCLUSION

Looking ahead, Sheesley and Eckhardt hope to reunite all of the rubbings that appeared in the windows of the Bonwit Teller Department Store. The exhibition of these delicate, nostalgic, and ghostly images lifted from the streets of New York City by Dienes would be a significant contribution to the revival of the artist's legacy. As Dienes steps out from the shadows to claim her rightful spot on the walls of museums and in the records of art history, this ongoing endeavor honors her philosophy and aesthetic while restoring and preserving the artifacts crafted by her hand. It also highlights the important role of a conservator when considering the trajectory of acquisitions, collection care, and education within an institution. The VMFA is proud to share this information in an effort to benefit other institutions, conservators, and scholars as interest in Sari Dienes' work heightens.

Fig. 11. Samantha Sheesley demonstrating Dienes' printing process.

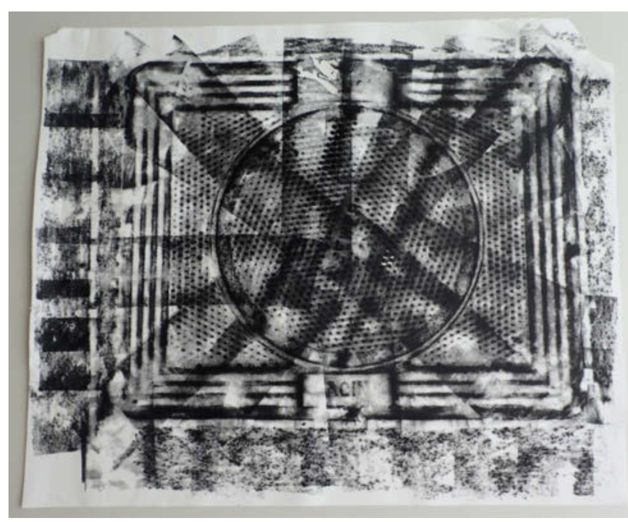


Fig. 13. Rubbing of manhole cover by Sheesley on paper.

ACKNOWLEDGMENTS

This project would not have been possible without Barbara Pollitt, Rip Hayman, and Sarah Eckhardt. Without their vision and noble efforts, there would be few traces of Sari's work and little momentum to restore what remains. Many thanks to the VMFA for supporting conservation and investing in Sari Dienes' work. The VMFA is fortunate to have such a talented and dedicated team. Many individuals from numerous departments offered their time and talent to make this project and its presentation a success: the VMFA Conservation Department, the VMFA Imaging Department, the VMFA Registration Department, and the VMFA Studio School, with special thanks to Stephen Bonadies, Heather Emmerson, Ainslie Harrison, Briget Ganske, Karri Richardson, Mary Holland, Frank Saunders, and Rosalie West. Finally, the location and identification of manhole covers in New York City would not have been successful without Seth Lake.

REFERENCES

Hedden, M. 1958. Surface printing as a means of recording petroglyphs. *Society of American Archaeology* 23 (4): 435–439.

Martin, H. 1991. My name is Sari Dienes: 'S' as in sugar, 'A' as in art. In *Sari Dienes 1950-1970*. Verona, Italy: Galleria La Giarina. 3–9.

Sari Dienes/Life/1940-1959. *Sari Dienes Foundation*. Accessed March 13, 2017. http://www.saridienes.org/life/index.html

Zeller, K. 2008. *Making her mark: Sari Dienes and her street rubbings in 1950s New York*. Ph.D. diss., School of the Art Institute of Chicago.

SAMANTHA SHEESLEY
Paper Conservator
Virginia Museum of Fine Arts
Richmond, VA
samantha.sheesley@vmfa.museum

HSIN-CHEN TSAI AND TANYA UYEDA

Line Up, Back to Back: Restoration of a Korean Buddhist Sutra in Accordion Book Format

ABSTRACT

East Asian Buddhist sutras are sometimes mounted in accordion book format and are commonly seen in China, Japan, and Korea. Sutra text is written mostly in gold or silver on indigo dyed paper. The indigo papers were either brush or vat dyed, lined with layers of paper, and then joined together as needed. A long, horizontal section of indigo paper may be folded into narrow pages, with wooden or paper covers attached to the ends. A Korean Buddhist sutra, *Dirghagama Sutra*, in 10-leaf accordion book format with both top and bottom paper covers was brought in for treatment to the Asian Conservation lab at the Museum of Fine Arts, Boston. Many of the condition problems of this sutra were likely linked to its function as a personal religious item. Problems included damage and losses due to excessive handling, an embossed circular impression likely from a vessel of some sort, substantial dirt and soiling, unknown attachments, and crude repairs (tape). Major treatment involving the disassembly and remounting of the sutra had to be considered to stabilize the sutra and permit its safe display and future handling.

This article presents the examination, documentation, and treatment of a Korean Buddhist sutra. Treatment included surface cleaning, structural stabilization, disassembling, tape removal, infilling, lining, and mounting. Conservators overcame several challenges, such as unifying the size of pages, infilling missing sections along folds, and readhering the front and back with fold lines aligned. During the course of treatment, several interesting discoveries were made involving the interior structure of the sutra, as well as the materials used to create the object. It is hoped that this case will be useful for the future conservation of other similar sutras mounted in accordion book format.

Presented at the Book and Paper Group Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

INTRODUCTION: KOREAN BUDDHIST SUTRA IN ACCORDION BOOK FORMAT

Korean Buddhist sutras can sometimes be mounted as an accordion book or in scroll format. During the Goryeo period (918-1392), indigo blue, ochre, and ivory white colors were used for Buddhist sutras, with indigo blue the most common color that appeared on earlier sutras. Sutras were produced by members of the ruling class or their families as a way to pray for the nation, their ancestors, or family members. Sutras were also produced when major national temples were built (Pak 2003).

Goryeo period sutras in accordion book format usually included several of the following elements: covers, a frontispiece (illustration), text, and a dedicatory (fig. 1). The covers were usually decorated with lotus flowers and a title slip with a lotus seat and canopy, which are two Buddhist symbols, in gold or silver. Some of the sutra covers that we see today have lost most of the silver pigment, with only gold pigment remaining. The frontispieces are often illustrated with scenes of the Buddha preaching and are decorated with borders of three-pronged pestles and wheel motifs. The composition of the preaching scenes may have been influenced by printed Buddhist sutras transported from Song dynasty China (Suan Huang 2011) (fig. 2). The text of the sutras was usually written in gold or silver with 14 or 17 characters per column. The dedicatory indicated the purpose, donors, and the date of the creation of the sutra.

For research, one of the authors viewed several confirmed Goryeo dynasty sutras in the United States and Korea, and also interviewed a modern-day sutra artist, Kyeongho Kim.[1] The interview with Kim focused on materials and the art form of making sutras since Kim has been studying and copying Goryeo dynasty sutras using traditional techniques.

ACCORDION BOOK FORMAT

There are two documented Goryeo period Korean sutras in U.S. collections. One is in the collection of the Metropolitan

Fig. 1. The top cover and frontispiece of *Illustrated Manuscript of the Lotus Sutra* from the Metropolitan Museum of Art's collection.

Museum of Art, and the other is in the collection of the Cleveland Museum of Art (CMA). The same author also viewed two additional sutras from the collection of the National Museum of Korea in Seoul. The description and comparison of these sutras are shown in table 1.

The height of each sutra page differed (between 20.7 and 35 cm), but the width of the pages was similar (about 11 cm). With exception of the CMA's sutra, the sutras' structure consisted of papers with a width of 55 to 60 cm that were joined by about one seam every five pages (fig. 3). Inscriptions could be seen at the seams (overlapping area at back) in some sutras, and they often indicated the sutra's name and the order of the sheets to be connected (fig. 4). The covers could be a separate piece with layers of paper to attach to the first sheet of the sutra, or they could be the first sheet and last sheet of the sutra itself folded over.

SUTRA PRODUCTION

In the interview with Kyeongho Kim, he mentioned that the sutra supports—the indigo papers—are usually acquired directly from art supply shops. These indigo papers were made using brush dye or vat-dyed techniques. The indigo papers are sized with animal glue and then burnished using a stone, bone, or anything with a hard surface. This process may be repeated at least three times until the indigo papers appear shiny and smooth and become slightly water resistant to avoid bleeding during the sutra writing or painting. The indigo papers are then lined and joined into accordion format. The covers are made from many paper layers built up to form a laminate structure.

Fig. 2. Wang Yi and others, Lotus Sutra, Song dynasty, woodblock print, Taipei Palace Museum, *A Special Exhibition of Illustrations of the Lotus Sutra* Plate 7.

A 99% gold powder is used as pigment and animal glue as binding media. After mixing the gold pigment and animal glue in a small dish, Kim lets the mixture set for some time and then pours off the impurities that rise to the surface in the dish. He may repeat this process up to three times. During painting and writing, he changes the water in the paint mixture every hour; he replaces the whole thing after 1 to 2 days. Kim also mentioned how the climate in the studio impacted the painting process. He preferred to keep the studio at 70%RH and the temperature between 25°C and 45°C, depending on the different thickness of the painting lines desired. For example, when drawing 1-mm lines, the temperature of the studio should be around 25°C; when drawing 0.2-mm lines, the temperature of the studio should be around 30°C; and when drawing 0.1-mm lines, the temperature of the studio should be around 35°C. The thinner lines required the higher temperature so that the media on the brush had good flow. He also polished the gold on the sutra with bone folder after it was done.

THE CONDITION OF *DIRGHAGAMA SUTRA*

Dirghagama Sutra was inscribed with the date 1372. It was a 10-leaf sutra in accordion format with both top and bottom paper covers. The sutra contains Agama sutra text and paintings including the depiction of a Buddhist assembly with deities on one side and three Bodhisattvas and a heavenly king on the other side, and an inscription including a date and a list of donors and their deceased ancestors (fig. 5).

The sutra text and illustrations are written and painted with metallic pigment on blue paper, each leaf measuring 25 x 9.5 cm. The pages of the sutra were created by laminating at least four layers of paper together, with the distinct front and back sections each lined with one layer, creating two sets of two-layer laminates attached back to back. However, close examination revealed that the inner linings did not extend the length of the sutra, so the structure of the sutra appeared uneven. The covers were created by several layers of colored papers laminated together.

White and yellowish accretions were present on the inside front cover, and the front of pages 1 and 8. These appeared to be associated with water or other liquid migration (fig. 6). These accretions were analyzed using FTIR analysis, indicating that they were primarily calcium carbonate. Pressure-sensitive tape was used on tears and losses in the

Title	Illustrated Manuscript of the Lotus Sutra	Guardian Deities of the Avatamsaka Sutra	Illustrated Manuscript of the Lotus Sutra	Avatamsaka Sutra (Hwaomgyong)
Accession No./Collection of	Bongwan 5053/NMK	Bongwan 12728/NMK	1994.207/MET	1994.25/CMA
Dimensions of Pages	28.4 x 10.9 cm	35 x 11.7 cm	22.9 x 11.4 cm	30.9 x 11 cm
Thickness of the Papers	0.14–0.22 mm	—	About 0.13 mm	About 0.1 mm
Thickness of the Cover	0.6–0.8 mm	—	About 0.6 mm	—
Length of One Section	Every 5 pages (about 55 cm)	Every 5 pages (about 60 cm)	Every 5 pages (about 60 cm)	Every 9 pages (about 100 cm)

Table 1. Measurement of Four Goryeo Period Sutras in the U.S. and Korean Collection

original paper support, along the vertical fold between pages 8 and 9 (on both the front and back surfaces), to the right of the *Bodhisattva* on the reverse of page 6, diagonally along losses on the front and reverse of page 2, and horizontally between the top edges of the front of pages 6 and 7 (fig. 7).

There were losses to the original paper support throughout, but the worst areas were as follows: the bottom edge of the front cover; outside vertical edge of the back cover; entire top section of pages 8, 9, and 10; and partial loss of the top section of page 7 (also seen in fig. 6). In addition, page 3 had two large areas of loss, the reverse of page 5 along the top edge, the reverse of page 5 central right, and page 10 front at center. Some of these losses were possibly due to insect damage.

One of the more intriguing issues was that some areas where the interior structure of the paper support was misaligned caused uneven thickness. Most of the corners of the pages showed damage from fold lines. The metallic media had loss, abrasion, and discoloration throughout.

The front cover had a layer of pink fibers throughout the top surface. This appeared to be a color transfer possibly from a pink-colored tissue paper that had been used as a wrapper by the previous owner. The highly soluble dye migrated into the original fibers of the sutra's front cover.

TREATMENT

After requisite photo documentation of the condition under visible light, transmitted light, raking light, and UV light, the overall format, losses, misaligned fragments, and tape repairs were recorded on a "condition map" on polyester sheeting. The surface was cleaned with a brush, vacuum, kneaded eraser, and scalpel as needed for removing dust, soil, and white mineral deposits. Tears were checked and stabilized together with fragments around the losses using rayon paper strips and a 1% methyl cellulose gel. Since the blue color in the support and metallic pigment were both stable in the water solubility test, a small amount of water was applied with a brush, then blotting paper squares were used to wick away dirt and discoloration. The white mineral deposits and brown dirt did not respond well to water. However, they were softened by moisture and could be picked up with a fine scalpel or another mechanical technique and then removed with controlled suction from a vacuum. The pink dye found on the covers was water soluble and could be removed by wicking with blotting paper squares.

The tape adhesive was softened using a heated spatula, then the carrier was gently removed by pulling at a flat angle (fig. 8). After removing the carrier, the sections of the sutra were detached from the folding line between page 8 and

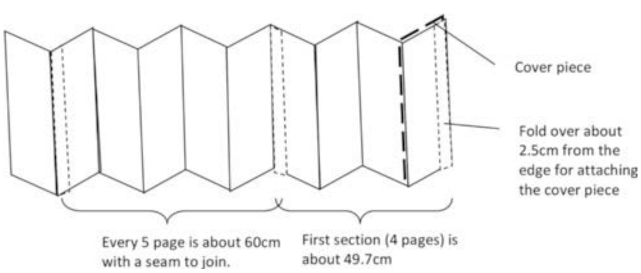


Fig. 3. Structure of Illustrated Manuscript of the Lotus Sutra from the collection of the National Museum of Korea.

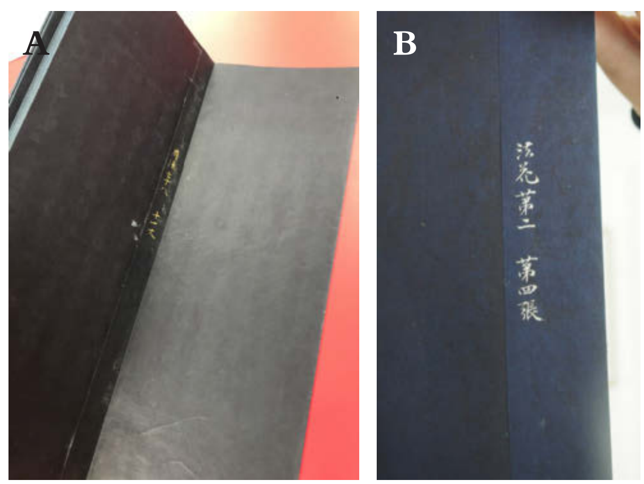


Fig. 4. (a) An inscription on the back of the sutra from CMA's collection that indicates "the 11th sheet of the 78th fascicle, translated in Restored Zhou dynasty (684-705)." (b) An inscription on the back of the sutra from Metropolitan Museum of Art's collection that indicates "the 4th sheet of the 2nd fascicle, Lotus Sutra".

Fig. 5. (a) The front of *Dirghagama Sutra* overall before treatment. (b) The back of *Dirghagama Sutra* overall before treatment.

page 9. A kneaded eraser and crepeline rubber eraser were used to remove adhesive residue mechanically. The fragments released from the tape areas were stabilized at the same time. The front covers were removed from the sutra mechanically using a bamboo spatula. The front and back of the main body of the sutra were gently separated as well (fig. 9). Care was taken around the areas of loss. Any unattached fragments were held in place using rayon paper strips and 1% methyl cellulose gel as needed.

After disassembly, it was discovered that the structure of the sutra was composed of two sections of laminate, one longer than the other and joined together in a complex overlap at page 7. The structure of the joined area is illustrated in the following and was made up of at least eight paper layers irregularly layered on top of each other. Some of the inner paper layers (linings) emerged through uneven areas on the surface of the sutra. Several of these exposed inner linings had been directly inscribed with text and images using the metallic pigment (fig. 10). These observations resulted in

Fig. 6. White and yellowish accretions at the front of page 8; large losses along the entire top section of pages 8, 9, and 10 and partial loss of the top section of page 7.

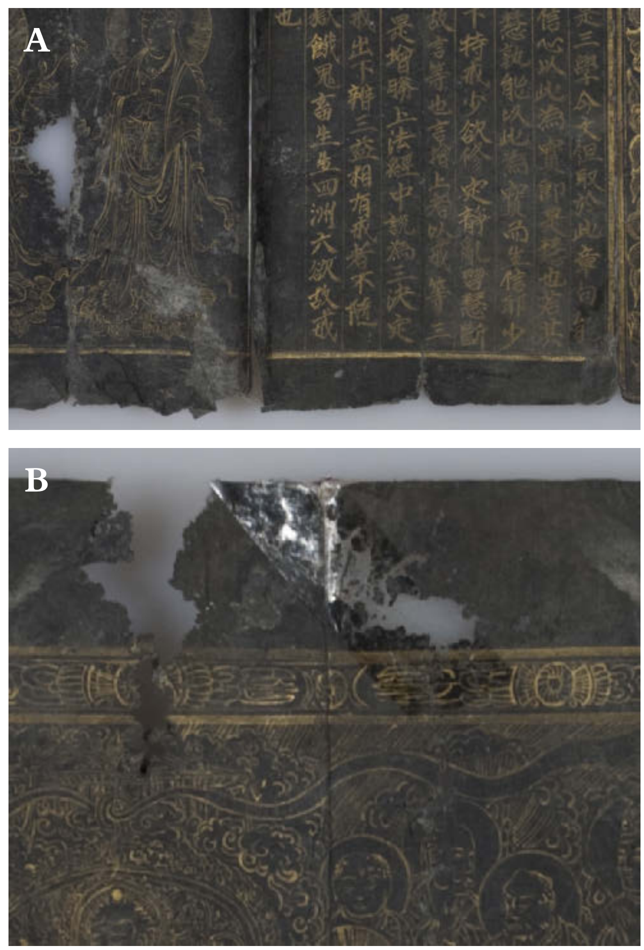


Fig. 7. (a) Tape along the vertical fold between pages 8 and 9. (b) Tape applied diagonally along losses on the front of page 2.

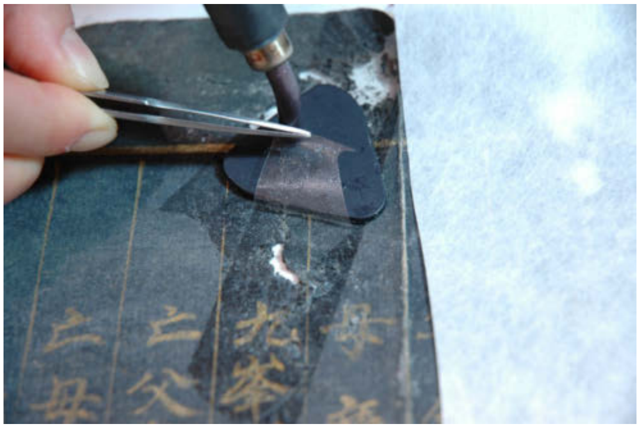


Fig. 8. The carrier was gently removed by pulling at a flat angle after applying heat.

the decision to preserve all of the paper layers for the reasons described in the next section.

Scientific analysis indicated that the tape used for repairs on the sutra was rubber based. It appeared tacky, sticky, and transparent, which suggested that it was in the early stages of aging and would require a low-polarity solvent to remove (Feller and Encke 1982). A solvent test was undertaken to determine the most effective solvent solution to clean the tape residue. Toluene, acetone, and ethanol were all tested by applying them to a piece of tape carrier removed from the sutra, and the result shows that toluene had the best and most immediate cleaning effect for the tape residue. However, a solvent that works more slowly and is more controllable is preferred when used on the actual object. Several more solvent tests were undertaken to determine the optimum mixture. Acetone was mixed with toluene, and this made the solvent mixture more polar and slowed the cleaning for more control. The solvent mixtures were tested on pieces of tape removed from the sutra, and the test results are shown in table 2.

A (1:2) mixture of toluene:acetone was determined to be the optimum cleaning solvent for the tape residue on the

Fig. 9. Separating the front and back of the main body of the sutra using a bamboo spatula

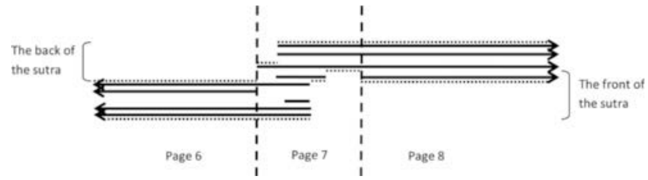


Fig. 10. Structure of the joined sections on page 7.

sutra because it could achieve an effective and controllable cleaning process. The solvent mixture was spot-tested on the paper support and the pigment on the sutra, and they were fairly stable. The solvent mixture was applied to the back of the sutra using a small brush. Outlines of the tape areas were traced on tracing paper for the conservator to use as a guide for the tape residue placement when working from the back. To avoid tide lines, the cleaning treatment was done with a suction platen underneath to remove the extra solvent mixture.

REMOUNTING

A description of the wet treatment process related to the remounting of the sutra, such as infilling, lining, and reassembly back to accordion book format, follows.

The interior structure of the main body of the sutra was not consistent in the number of linings and in the positioning of these linings. Some previous linings did not extend all the way to the edges of the sutra; some linings showed through abraded areas on the surface of the sutra, or in corners, and had lines from borders, text, or image on them. To preserve as much of the surface text and image as possible, and also to leave information intact relating to the sutra structure, it was decided to preserve rather than replace all layers of the previous linings. Sometimes this involved infilling the lining papers and the sutra surface to create a more uniform structure.

Once the sutra was moistened, the previous linings loosened and could be peeled off temporarily to access the sutra surface for treatment. These were put back in place after infilling. A *misu*-type Japanese paper was chosen for its similar characteristics to the original for filling losses. The infill papers and new lining papers were toned to three different shades using stick pigments of indigo earth colors and carbon ink to match the tones in different areas of the sutra. Losses were infilled using starch paste with a slight overlap, and previous linings were placed back where they had been using starch paste.

Solvent Mixtures	Cleaning Results
Toluene:Acetone (2:1)	Cleaned the adhesive right off from the tape.
Toluene:Acetone (1:1)	Good cleaning effect.
Toluene:Acetone (1:2)	Good cleaning effect, but it needed repeated applications to achieve the desired cleaning result.

Table 2. Result of Solvent Mixtures Test

There was concern that the paper size could expand unevenly during wet treatment. The folding lines of the front and back section needed to be aligned, meaning that every page size must remain the same. To control distortion, the outline of the front sutra section was traced once it was moistened and fully expanded overall (fig. 11). This template was used as a guide for the other section of the sutra during the lining process to ensure similar expansion. For infilling the large areas of loss between the detached pages 8 and 9, another template based on two average-size pages was traced on a polyester sheet to determine the size of the infills (fig. 12) after placing the long section and short section of sutra with templates underneath as guides. After infilling and reattaching the previous linings, each section of the sutra was pressed between blotting paper under light weights.

New linings to both the front and back sections were applied overall as a support. Each page of the sutra was carefully moistened using the traced outline as a guide. This allowed for maximum control in the expansion of the sutra. Once the front and back sections each had an overall lining for support, the rates of expansion became more uniform. Paper reinforcements were set into every fold after adding the lining (fig. 13). The front and back sections of the sutra with new linings were then stretch dried on a drying board.

The front and the back sections of the sutra were then reattached using starch paste. Although the expansion of the front and the back sections were more uniform as a result of lining, the size of each page on the front section and back section was still slightly different. In addition, with one section of the sutra facing down, and with the extended lining paper margins, it was difficult to know where the folds and outer edges were to align them accurately. Therefore, the outline of the sutra was

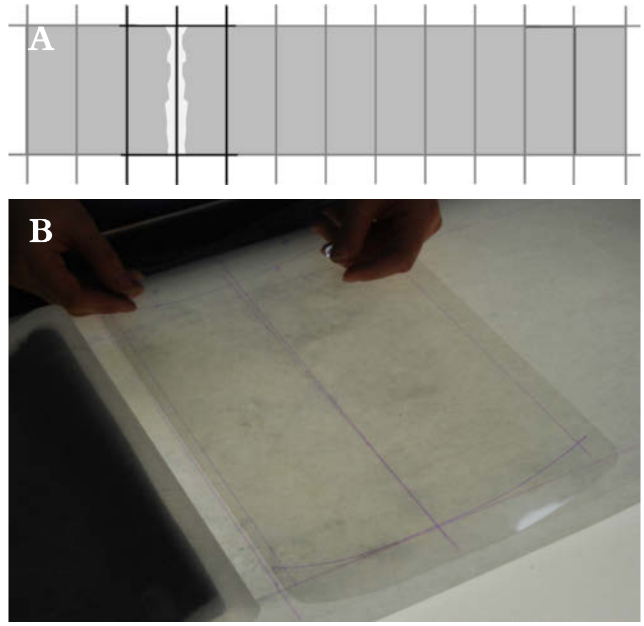


Fig. 12. (a) Several templates were used to determine the infills between page 8 and page 9. (b) Placing the template based on two average size pages, shown in darker color.

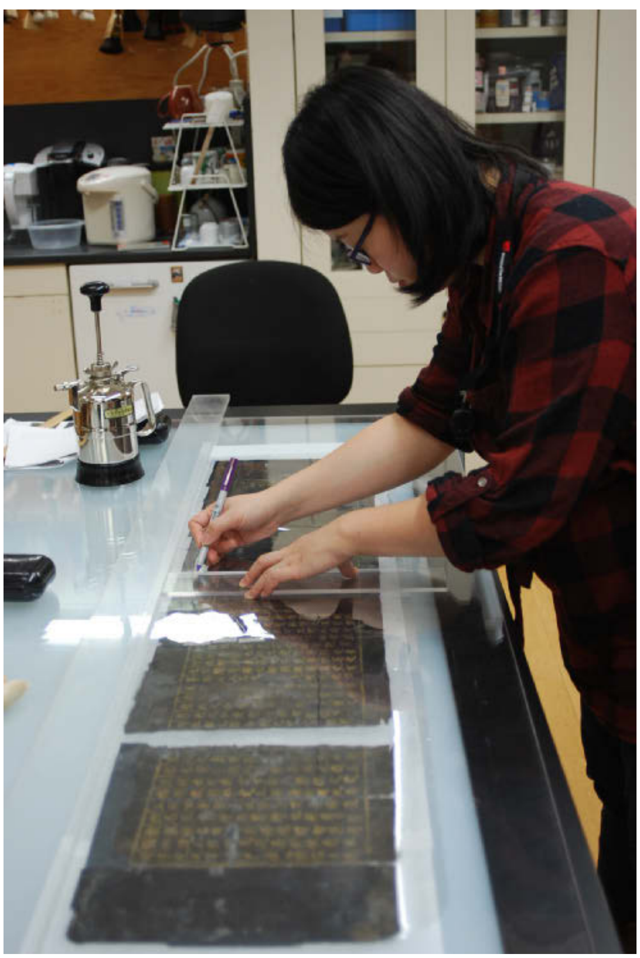


Fig. 11. Tracing the outline of moistened sutra on Mylar as a template

Fig. 13. Paper reinforcements were set into each fold after adding the lining.

Fig. 14. Another template of the whole section of the sutra was made.

Fig. 15. After pasting the bottom sutra and removing the Mylar, the top sutra was laid down page by page and smoothed by hand. Notches cut to indicate position of fold lines can be seen on the paper margins in this photo.

traced again to determine every fold line and the position of the top and bottom edges (fig. 14). The new top and bottom edges were slightly askew from the original ones to accommodate the irregular dents and losses along the edge, which also meant that the sutra would be slightly larger in height. Notches were cut at the top and bottom of the extended paper lining to indicate where the folds and top and bottom edges were for proper positioning. One section of the sutra was moistened with the outline guide underneath. One piece of polyester sheeting was placed as a moisture barrier while positioning the top sutra. The top sutra was placed with the central folds aligned, then verified that the other folds aligned. Each page was still slightly different, so conservators gently manipulated each page while applying more moisture with a brush to get the folds in close alignment. Once the top sutra was in position and expansion was set, the top sutra and polyester sheeting was flipped halfway aside and paste was applied on the bottom sutra, brushing vertically (to avoid extra horizontal expansion). Half of the polyester sheeting was then cut off, and the top sutra was laid down page by page with more moisture added as needed to expand and achieve proper alignment. In the event a top page was bigger than a bottom page, the fold first was laid down and the page evenly smoothed trying not to create any creases. Good adhesion was ensured by gentle smoothing by hand, not brushes, to avoid the pages being brushed out of their positions (fig. 15). After checking that each page was attached with no creases, overall brushing was done to ensure that both sections of the sutra had good contact.

The sutra was flattened on a drying board. After flattening, the sutra was burnished on both sides with polishing beads through a protective layer of Reemay to ensure proper and even adhesion between the paper layers. The sutra was then folded into accordion format along the original folds using a straight edge and bone folder (fig. 16). The inner covers were attached to the sutra using starch paste and then pressed between blotting papers, wood boards, and weights. After the covers dried, the edges of the sutra were trimmed of excess lining paper, and the whole sutra was pressed, folded, and put under weights for 1 to 2 weeks.

As a result of treatment, the sutra was safer to handle and display. Deteriorating pressure-sensitive tape used in repairs was removed, losses were filled, and folds were reinforced. The uneven internal structure of the sutra was addressed by infilling interior lining papers and applying overall linings to the front and back sections. The appearance of the sutra was improved by reducing the white and yellow accretions, resulting in greater legibility of text. These results would not have been achieved by minor treatment. (figs. 17, 18).

CONCLUSION

Books or sutras in accordion format experience more frequent handling than Asian artworks in other formats because of their function. When major treatment becomes necessary

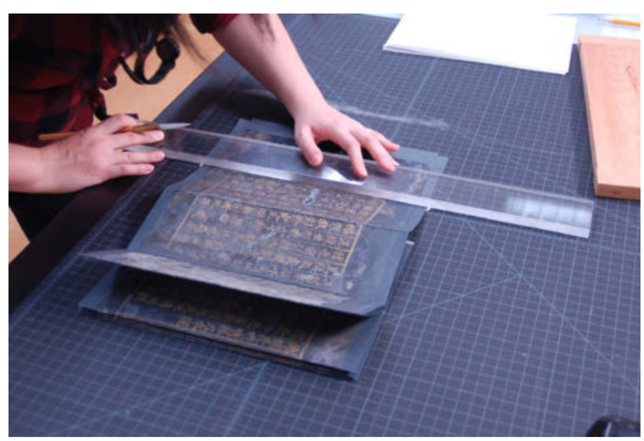


Fig. 16. Folding the sutra back to accordion book format.

Fig. 17. (a) The front of *Dirghagama Sutra* overall after treatment. (b) The back of *Dirghagama Sutra* overall after treatment.

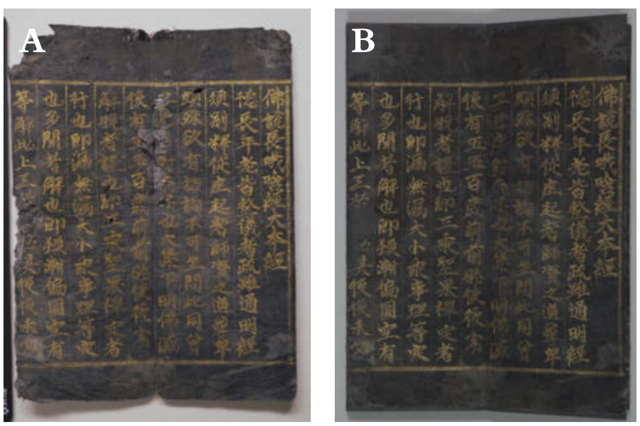


Fig. 18. (a) Two pages of *Dirghagama Sutra* before treatment. (b) Two pages of *Dirghagama Sutra* after treatment.

to address condition problems arising from excessive handling and use, one of the challenges lies in reassembling this format with folds and pages properly aligned.

In the case of the Korean Buddhist *Dirghagama Sutra*, several levels of approach were used to control the expansion and sizes of the pages:

1. *The use of templates*. Several different templates were made to document the position of each page, especially when one section of the sutra was moistened and expanded during wet treatment and during the process of lining. A template was also used as a guide to control expansion of the two sections during the process of lining and reattachment.
2. *An overall lining as support*. In this case, the interior structure of the sutra was not even, making some areas with more paper layers absorb more moisture and expand more than others. Providing an overall lining helped hold the paper layers together and control rates of expansion when applying moisture from the back/lining.
3. *Controlling the amount of moisture*. Even with the same rate of expansion during wet treatment and with overall linings to both sections of the sutra, the sizes of the pages were still slightly different. Once the central folds were aligned, even slight differences of each page could still cause increasing discrepancies in the folds progressing outward from the center. Conservators were able to control this by varying the amount of moisture applied relative to the alignment situation of both sections of the sutra.

ACKNOWLEDGMENTS

We would like to thank the following colleagues: Jacki Elgar, head of the Asian Conservation Studio; Jing Gao, Cornelius Van der Starr Conservator of Chinese Paintings; Joan Wright, Bettina Burr Conservator; Alison Luxner, associate conservator; Margaret Wessling, Morse Fellow for Advanced Training in Conservation; and Jiwon Ryu, Korean-Buddhist Painting graduate research intern. We are also grateful to the following people for their kind support for this research project: Yi-Hsia Hsiao, assistant conservator at the CMA; Kyeongho Kim, Korean Sutra artist; Dr. JuHyun Cheon, conservator of Paintings and Paper at the National Museum of Korea; KyungHee Yu, curator of Asian Art at the National Museum of Korea; Hwai-ling Yeh-Lewis, senior collections manager at the Metropolitan Museum of Art; Lori Carrier, senior department technician at the Metropolitan Museum of Art; Ping-Chung Tseng, assistant conservator of Asian Art at the Metropolitan Museum of Art; and Tsang-Miao Kuo, assistant conservator at the National Palace Museum, Taipei.

REFERENCES

R. L. Feller, and D. B. Encke. 1982. Stages in deterioration: The examples of rubber cement and transparent mending tape. *Studies in Conservation*. 27 (Suppl. 1), 19-23.

S.-S. Suan Huang. 2011. Media transfer and modular construction: The printing of Lotus Sutra frontispieces in Song China. *Ars Orientalis* 41: 135-163.

O. K. Kyeong-ho. 2014. Oegil Kim Kyeong-ho: Art Of 사경 (Sagyeong; 寫經). http://kafny.org/art-of-sagyeong/.

National Palace Museum. 1995. *A special exhibition of illustrations of the Lotus Sutra*. Taipei, Taiwan: National Palace Museum.

Y. Pak. 2003. Goryeo illuminated Buddhist scriptures: Transmission of text and images. In *Goryeo dynasty: Korea's Age of Enlightenment 918-1392*, ed. K. Paik Kim. San Francisco, CA: Asian Art Museum. 96-105.

NOTE

1. Kyeongho Kim is the author of *An Introduction to Sagyeong* (sutra writing/painting), the first unique publication on Sagyeong in modern times in Korea. In 1997, he won the grand prize in the first-ever Buddhist Scripture Transcribing Contest co-organized by the Jogye Order of Korean Buddhism and Eastern Calligraphers' Association. He has presented numerous solo exhibitions, including 15 shows organized by the Korean State. He has also taught traditional Sagyeong at universities, on Buddhist television channels, and at Dong-A Cultural Center. He has been invited by many prestigious organizations to give special lectures and demonstrations. As the highest authority in Sagyeong, he serves as the president of the Korean Transcribed Sutra Research Association.

HSIN-CHEN TSAI
Associate Conservator of Chinese Paintings
Museum of Fine Arts, Boston
Boston, MA
htsai@mfa.org

TANYA UYEDA
Associate Conservator of Japanese Paintings
Museum of Fine Arts, Boston
Boston, MA
tuyeda@mfa.org

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

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

MATTHEW COLLINS
Niels Bohr Chair of Palaeoproteomics
Statens Naturhistoriske Museum, Københavns Universitet
København, Denmark
matthew@palaeome.org

Presented at the Joint Book and Paper + Research and Technical Studies Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

CINDY CONNELLY RYAN, MICHELE YOUKET, DR. LYNN BROSTOFF, AND DR. ERIC BREITUNG

Revisiting Paper pH Determination: 40 Years of Evolving Practice in the Library of Congress Preservation Research and Testing Laboratory

The pH of paper is a fundamental indicator of its long-term stability and is routinely considered by conservators, cultural heritage scientists, and collection care professionals in the process of making decisions about collection storage, handling, and access policies. The results of pH are frequently considered as part of conservation treatment planning and are nearly always included in research studies related to paper preservation. An assortment of measurement methods are currently in use. This seemingly basic and familiar measurement, however, contains a depth and complexity that becomes apparent when pondering the differences between the industrial, ISO standard, and numerous published variant methods, including surface measurements, miniaturized methods, cold extraction, and hot extraction. Are the results comparable from the different methods? Which approach is best? Over the past few years, the Library of Congress Preservation Research and Testing Division (PRTD) has revisited its standard protocols for pH measurement of paper and board in the contexts of quality assurance needs for collection housing and exhibition materials, special collections needs, and scientific research samples. This talk will include a short discussion of the fundamentals of paper pH measurement, focusing on how aspects of sampling, sample preparation, and measurement method affect the results obtained. The various methods in use in our lab from the early 1970s to the present will be discussed, with a focus on our recent efforts to streamline our semiautomated measurements, to conduct direct comparisons between methods and to develop a reliable miniaturized pH determination method.

CINDY CONNELLY RYAN
Preservation Specialist, Preservation Research and Testing Division
Library of Congress
Washington, DC
crya@loc.gov

MICHELE YOUKET
Preservation Specialist, Preservation Research and Testing Division
Library of Congress
Washington, DC
myou@loc.gov

DR. LYNN BROSTOFF
Senior Chemist, Preservation Research and Testing Division
Library of Congress
Washington, DC
lbrostoff@loc.gov

DR. ERIC BREITUNG
Senior Research Scientist, Department of Scientific Research
Metropolitan Museum of Art
New York, NY
eric.breitung@metmuseum.org

Presented at the Joint Book and Paper + Research and Technical Studies Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

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

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

DR. ANDREW DAVIS
Chemist, Preservation Research and Testing Division
Library of Congress
Washington, DC
adavi@loc.gov

DR. FENELLA FRANCE
Chief, Preservation Research and Testing Division
Library of Congress
Washington, DC
frfr@loc.gov

Presented at the Joint Book and Paper + Research and Technical Studies Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

STACEY M. KELLY, JODIE UTTER, AMY V. WALKER, PhD, ASHLEY A. ELLSWORTH, PhD, AND JENNY K. HEDLUND

Characterization of the Aniline Dyes in the Colored Papers of José Posada's Prints Using Time-of-Flight Secondary Ion Mass Spectrometry to aid in Developing a Treatment Protocol for the Removal of Pressure-sensitive Tapes

INTRODUCTION

José Guadalupe Posada (1852–1913) was a Mexican Artist active during the turn of the 20th century. He has been dubbed by many scholars as the father of modern Mexican printmaking, producing thousands of illustrations during his lifetime. Posada's work was of paramount importance to the development of modern Mexican art. In the 20th century, Mexican muralists including Diego Riviera and José Clemente Orozco drew inspiration from Posada and acknowledged his influence on their work. His *Calaveras* were his most iconic images, skeleton caricatures that he popularized, produced for *Día de Muertos* (Day of the Dead) celebrations.

The Amon Carter Museum has approximately 400 prints attributed to Posada. The collection is in remarkable condition. With many of the prints retaining their bright colors. A recent survey of the works on paper collection highlighted a group of the Posada prints as "high-priority" treatment items. These prints contain oxidized pressure-sensitive tape (PST) residue, which is penetrating and weakening the short-fibered papers. The works affected in the collection are some of Posada's broadsides (figs. 1a-e), produced when he worked with publisher Antonio Vanegas Arroyo. Broadsides are penny pamphlets—ephemeral publications covering a wide range of topics. These broadsides were produced quickly and inexpensively, and they were circulated around much of Mexico.

The dyes that give these broadsides their vivid colors are synthetic organic dyes (also known as aniline dyes), which are extremely soluble in many solvents. Unfortunately, common PST removal techniques in paper conservation involve the use of solvents. This challenge led to the following research project, which was to characterize the aniline dyes in Posada's prints to develop a treatment protocol that would keep these highly soluble dyes intact during treatment.

Presented at the Joint Book and Paper + Research and Technical Studies Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

CHARACTERIZING THE ANILINE DYES

ANALYSIS OF DYES

When it comes to analyzing works of art, nondestructive in situ analysis is preferred. If samples are taken, they should be so inconsequential that the integrity and the appearance of the object are unaltered. This limitation of sample size, coupled with the fact that aniline dyes have high tinting strengths (resulting in extremely low dye content within a sample), make organic dyes particularly challenging to analyze.

Analyses of organic dyes in paper are usually done using chromatographic or vibrational spectrometry techniques (Kirby and White 1996). Chromatographic techniques often require large samples and lengthy sample preparation involving dye extraction (Kirby and White 1996). Noninvasive spectroscopic methods such as infrared spectroscopy and reflectance UV/Vis spectroscopy have also been used for the analysis of dyes (Low and Baer 1977; Gillard et al. 1994; Kirby and White 1996; Casadio et al. 2010). However, these techniques are made complicated when applied to paper dye analysis due to the additional spectra from the paper substrate itself, as well as changes in the paper over time.

Raman spectroscopy has been used with some success for the nondestructive analysis of dyes (Guineau 1989; Massonnet et al. 2005). Unfortunately, the Raman signal is often swamped by the fluorescence from the colorants and other organic material present (Kirby and White 1996). Surface-enhanced Raman scattering (SERS) and Fourier transform (FT)-Raman are techniques that have been used to improve the Raman signal and reduce fluorescence in the analysis of dyestuffs. However, SERS requires the preparation and use of a SERS-active substrate, which introduces an additional step in the sample preparation process that is not always ideal (Mukhopadhyay 2010). Although FT-Raman is a suitable method for the in situ

Fig. 1a. Posada, José Guadalupe (1852–1913), *Guadalupe Bejarano en las bartolinas de Belen. Careo entre la mujer verdugo y su hijo,* ca. 1890-1913, intaglio print (39.9 x 29.9 cm). Amon Carter Museum of American Art, Fort Worth, Texas, 1985.20.

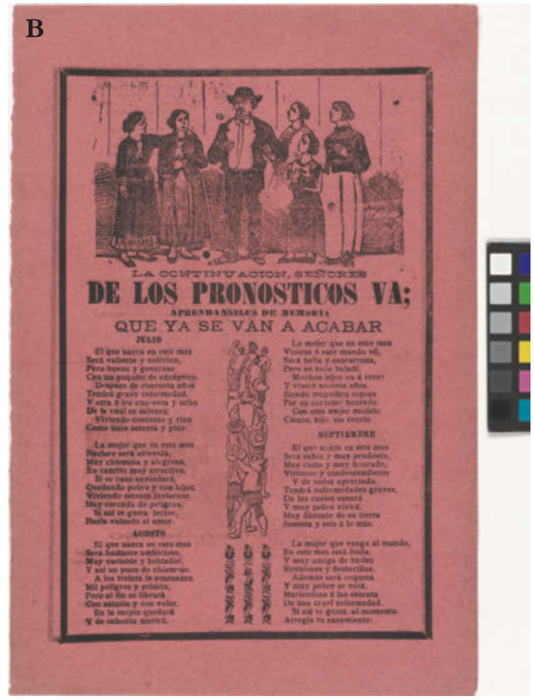


Fig. 1b. Posada, José Guadalupe (1852–1913*), La continuación, señores de los pronósticos va; apréndanlos de memoria que ya se van a acabar*, 1904, intaglio print (30.3 x 20.3 cm). Amon Carter Museum of American Art, Fort Worth, Texas. Gift of Dr. and Mrs. W. W. Moorman as a memorial to their son, Robert Maxey Moorman, 1981.47.

Fig. 1c. Posada, José Guadalupe (1852–1913), *Corrido dedicado al 16 septiembre de 1897*, after 1897, intaglio print (20.3 x 29.9 cm). Amon Carter Museum of American Art, Fort Worth, Texas, 1978.84.

Fig. 1d. Posada, José Guadalupe (1852–1913), *Ya llegó calavera de la penitenciaria, no se arruguen cueros viejos oue [sic] aquí está Rafael Buendía*, ca. 1890-1913, intaglio print (40.3 x 30 cm). Amon Carter Museum of American Art, Fort Worth, Texas, 1978.182.

Fig. 1e. Posada, José Guadalupe (1852–1913), *El Mosquito Americano*, ca. 1890-1913, intaglio print (29.9 x 19.8 cm). Amon Carter Museum of American Art, Fort Worth, Texas, 1978.119.

analysis of dyes on works on paper, it is limited in its capacity to identify yellow dyes or differentiate between different blue dyestuffs (Casadio et al. 2010).

A study by Casadio et al. (2010) used FT-Raman with success to identify some of the dyes used in Posada's prints. Unfortunately, FT-Raman was not able to characterize all of the dyes, particularly the dyes in the yellow Posada prints. Raman techniques interrogate the vibrations of bonds within a molecule, and some dyes (especially yellows) do not produce unique vibrational frequencies to identify them from a list of possibilities. In this study, a mass spectrometry method was chosen to complement the results obtained from the Casadio et al. (2010) FT-Raman study of Posada's prints.

TIME-OF-FLIGHT SECONDARY ION MASS SPECTROMETRY

Time-of-flight secondary ion mass spectrometry (TOF-SIMS) is a surface analytical technique capable of collecting chemical information from inorganic and organic materials. It requires extremely small samples and little to no sample preparation. TOF-SIMS has been used in the cultural heritage field in a variety of applications, including the study of polymers (Abel and Coppitters 2008), investigating surface changes on textiles (Carr, Mitchell, and Howell 2004), organic pigment analysis (Van Ham et al. 2005), and the identification of dyes on textiles (Lee et al. 2008). In TOF-SIMS, the surface of the sample is bombarded by high-energy ions, leading to the ejection of both neutral and charged (+/-) species from the surface of the sample (fig. 2). These ejected molecules are accelerated to a specific energy at a fixed distance and detected with an analyzer, producing spectra. TOF-SIMS is a type of mass analyzer that can provide substantially higher sensitivity and mass resolution, and a much greater mass range (Walker 2013).

SAMPLES

The appropriate experimental parameters for TOF-SIMS analysis were set up by first testing the technique on dye samples taken from a dye manual contemporary to Posada's prints (fig. 3a). This dye manual, *Dyeing of Paper Pulp* by Julius Erfurt (1901) contains 157 swatches made from 34 different synthetic dyes and their mixtures. Encased in a book, the swatches remained protected from light, keeping their colors intense. Spectra were obtained from samples cut from this book. These reference samples were instrumental in setting the appropriate experimental parameters for TOF-SIMS

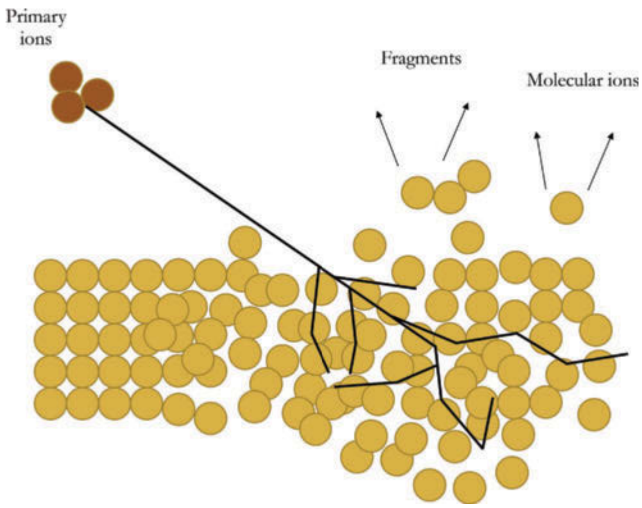


Fig. 2. Diagram showing secondary ion production during TOF-SIMS analysis. Adapted from Mazel and Richardin (2009).

analysis and also proved useful in gauging the feasibility of using TOF-SIMS with aniline dyes on paper (fig. 3b).

Five posada prints from the Amon Carter Museum's collection were selected for analysis based on color and dye intensity. They are listed here by color and accession number: Magenta (1978.84), Scarlet (1981.47), Orange (1986.20), Green (1978.182), and Yellow (1978.119). Each print was sampled by gentle scraping a tungsten needle over an existing loss and gathering the fibers onto double-sided copper tape.

INSTRUMENTATION

TOF-SIMS spectra were acquired using an ION TOF IV spectrometer (ION TOF Inc., Chestnut Hill, NY) equipped with a Bi liquid metal ion gun. The instrument consists of a load lock for sample introduction, preparation, and analysis chambers each separated by a gate valve. The pressure of the preparation and analysis chambers were maintained at less than 8×10^{-9} mbar. The primary Bi+ ions had a kinetic energy of 25 keV and were contained in an approximately 100-nm-diameter probe beam, which was rastered over either (500 × 500) μm^2 or (100 × 100) μm^2 areas during spectra acquisition. All spectra were acquired using a total ion dose less than 10^{11} ions/cm^2, which is within the static SIMS regime, and charge compensation was employed. The secondary ions were extracted into a time-of-flight mass spectrometer using a potential of 2000 V and were reaccelerated to 10 keV before reaching the detector. At least six positive and negative ion spectra were acquired for each sample. The peak intensities were reproducible to within ± 15% from scan to scan.

RESULTS

SIMS provides both elemental and molecular information on a submicron scale. Each peak in the spectra is a data point

Fig. 3. (a) Dye swatches from the dye manual *Dyeing of Paper Pulp* by Erfurt (1901). (b) TOF-SIMS instrument at University of Texas, Dallas.

(mass-to-charge ratio or *m/z*) that relates to a particular structural/chemical fragment. To identify the components in a sample, the ions in the spectra must first be identified. These ions indicate how the molecule breaks apart. Working backward, it is then possible to establish the molecular structure from which these ions came.

Aided by the Casadio et al. (2010) FT-Raman study, which includes a table of 20 widely used dyes in the 19th century paper industry, together with historical papers and books listing commonly used aniline dyes (Schweppe 1987), the dyes in the Posada samples were successfully characterized through a process of deductive reasoning.

The samples in this study have two components: the paper and the dye. It is necessary to first determine the common ions associated with the paper, after which the remaining ions are then used to ascertain which organic dyes are present in the sample. The fibers of the five Posada prints have common *m*/z peaks, indicating that these peaks come from the paper, and the papers are most likely the same/similar (probably wood pulp). The remaining peaks are the unique mass-to-charge peaks for each fiber that come from the dye (table 1).

Table 2 shows TOF-SIMS analysis for all five Posada prints, for which the accession number, paper color, TOF-SIMS result, and unique *m/z* peaks associated with the dyes are given for each print. The known vulnerabilities of each identified dye are also listed. Orange II, Cotton Scarlet, Phloxine BBN, Malachite Green, and Metanil Yellow were detected. The successful identification of Metanil Yellow in the yellow Posada print is significant, as yellow colorants are notoriously difficult to characterize. These findings correspond to the results obtained from the Casadio et al. (2010) FT-Raman study of the dyes in Posada's prints, further validating the methodology used in this project. These results also confirm that TOF-SIMS is a suitable method for the identification of dyes in works of art on paper. This information provided a better understanding of the known sensitivities of these dyes with regard to treatment.

DEVELOPING A TREATMENT PROTOCOL FOR THE REMOVAL OF OXIDIZED PSTS AND ADHESIVES

EXPERIMENTAL SETUP

Surrogate Samples

A group of surrogate samples were made using ephemera from the turn of the 20th century that contained aniline dyes (a similar time frame to Posada's prints). A group of colored and noncolored papers were chosen. The samples were divided to allow the testing of a variety of tapes/adhesives, as well as a variety of removal methods (fig. 4).

Orange Fiber (+)	Orange Fiber (–)	Scarlet Fiber (+)	Scarlet Fiber (–)	Magenta Fiber (+)	Magenta Fiber (–)	Green Fiber (+)	Green Fiber (–)	Yellow Fiber (+)	Yellow Fiber (–)
57	62	69	63	69	35	69	71	69	71
69	70	71	66	71	37	71	80	71	80
71	78	73	70	95	79	95	96	73	265
95	86	95	78	147	81	97	127	95	281
133	109	147	85	178	127	109	137	109	311
147	127	191	110	207	175	147	183	147	325
207	140	207	140	221	265	207	203	165	339
221	155	221	142	281	269	221	223	207	473
281	188	265	188	343	357	281	253	221	
341	214	267	190	358	473	283	257	265	
359	222	281	224			301	265	279	
368	237	305	250			329	281	281	
	245	359	300			343	293		
	258	523				358	309		
	260	551				372	311		
	271					385	325		
	273						353		
	281						357		
	283								
	297								
	392								





Table 1. Unique Data Points (*m*/z Peaks) for the Five Posada Prints Analyzed with TOF-SIMS

Accession Number	Color	*m/z* Peaks (Positive)	*m/z* Peaks (Negative)	TOF-SIMS Analysis Results	Vulnerabilities
1985.20 	Orange	57, 133, 341, 359, 368	62, 70, 78, 86, 109, 127, 140, 155, 188, 214, 222, 237, 245, 258, 260, 271, 273, 281, 283, 297, 392	Orange II (Acid Orange 7)	Soluble in water, ethanol, glycol ethers; sensitive to pH changes
1981.47 	Scarlet	73, 191, 265, 267, 305, 359, 523, 551	63, 66, 70, 78, 85, 110, 140, 142, 188, 190, 224, 250, 300	Cotton Scarlet (Acid Red 73)	Soluble in water and alcohol
1978.84 	Magenta	178, 343, 358	35, 37, 79, 81, 127, 175, 265, 269, 357, 473	Phloxine BBN (Acid Red 92)	Soluble in water
1978.182 	Green	97, 109, 283, 301, 329, 343, 358, 372, 385	71, 80, 96, 127, 137, 183, 203, 223, 253, 257, 265, 281, 293, 309, 311, 325, 353, 357	Malachite Green (Basic Green 4)	Soluble in water, ethanol, glycol ethers
1978.119 	Yellow	73, 109, 165, 265, 279	71, 80, 265, 281, 311, 325, 339, 473	Metanil Yellow (Acid Yellow 36)	Soluble in water, alcohol, benzene, ether, acetone

Table 2. List of Posada prints analyzed with TOF-SIMS

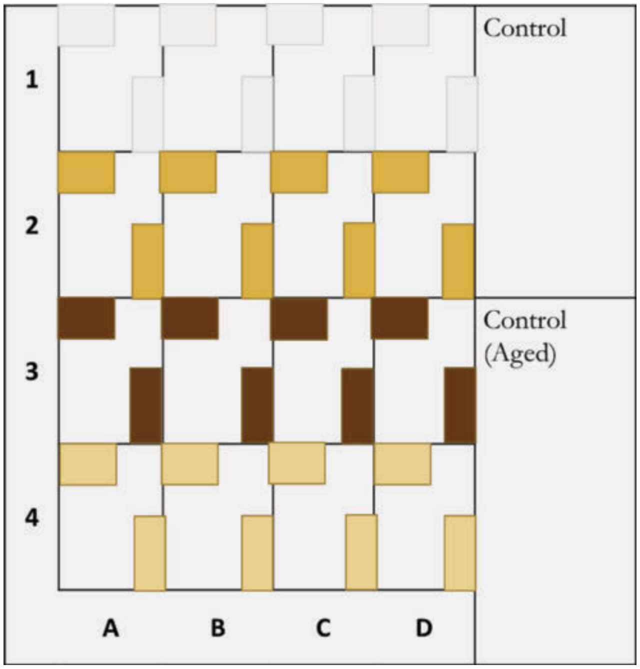


Fig. 4. Samples were divided according to this diagram, allowing the testing of the removal of a variety of tapes/adhesives, as well as a variety of methods. (1) Scotch magic tape: acetate backing; acrylic adhesive; (2) 3M 2214 paper tape: crepe paper backing; rubber adhesive; (3) gummed brown paper tape: Kraft paper backing; starch adhesive; (4) Slime rubber cement: rubber-based adhesive; (A) local application of solvent and suction table; (B) solvent and Gellan gel; (C) Gore-Tex with solvent; (D) extras.

Artificial Aging

After the tape/adhesives were placed, the samples underwent thermal aging at 80°C for 35 days until the tape deterioration mimicked the deterioration seen on the Posada prints (Stage II: oxidation stage). At the oxidation stage, the tape adhesive has begun to degrade, causing it to darken, turn sticky and oily, and seep into the paper—causing translucency.

SELECTION OF SOLVENT

Solvents Tested

Using the Teas chart, a variety of solvents were tested ranging in polarities, including xylene, toluene, methylene chloride, chloroform, acetone, and methyl ethyl ketone. As adhesive ages, it becomes more polar, requiring more polar solvents to remove. The higher the polarity of the solvent, the more likely the dyes in the paper will solubilize. The challenge in this study was finding a solvent that would solubilize the adhesive while keeping the dyes intact.

Absorbency and Dye Stability Tests

The first priority was to identify the solvents that would work well with the paper and not solubilize the dyes. Absorbency tests were conducted on the controls: the samples were placed over Whatman filter paper, and a drop of solvent was deposited on the surface. The time taken for the solvent to be absorbed in the paper was measured. The formation of tide lines and dye bleed was also noted to keep track of dye solubility (figs. 5a-c).

Preliminary Adhesive Reduction Tests

To identify the solvents capable of solubilizing the various adhesives, preliminary adhesive reduction tests were conducted. The samples were flooded with solvent and the adhesive scraped off with a spatula. Effectiveness in removing the adhesive and dye bleed were considered. A handheld UV torch was used to keep track of dye bleeding and adhesive residue in the paper.

Solvents Selected for Each Color/Adhesive Combination

Following these tests, the selected solvents for each color/adhesive combination were predominately xylene, methylene chloride, toluene, and chloroform, which were among the least polar of the solvents originally tested (table 3).

PRIOR TO TREATMENT

Before treatment, tape carriers were removed mechanically with heat where possible. Gellan gel samples were humidified using a Gore-Tex sandwich. These steps were taken to simulate real treatment scenarios.

LOCAL APPLICATION OF SOLVENT AND SUCTION

Technique

While on the suction table, the selected solvent was locally applied using a dropper or swab. Suction would then pull the solvent and solubilized adhesive through the paper onto a blotter.

Observations

This method was very effective in removing the solubilized adhesive residue from the samples. It showed good results on samples with and without carriers still attached (fig. 6a). Tide lines formed during treatment but were mostly controllable; some bleeding of the pink and yellow dyes occurred (fig. 6b). This method is not suitable for fragile samples, as it can cause additional physical stress and damage.

SOLVENT AND GELLAN GEL

Technique

Gellan gel was tested due to its availability in the Amon Carter Museum's conservation lab. A 3% Gellan gel was made to ensure high absorption and minimize the release of moisture from the gel. Figure 7 shows the treatment setup. Solvent was applied to the underside of the gel and placed on the samples in 15-minute applications.[1]

Fig. 5a. Conducting absorbency and dye stability tests on a control sample.

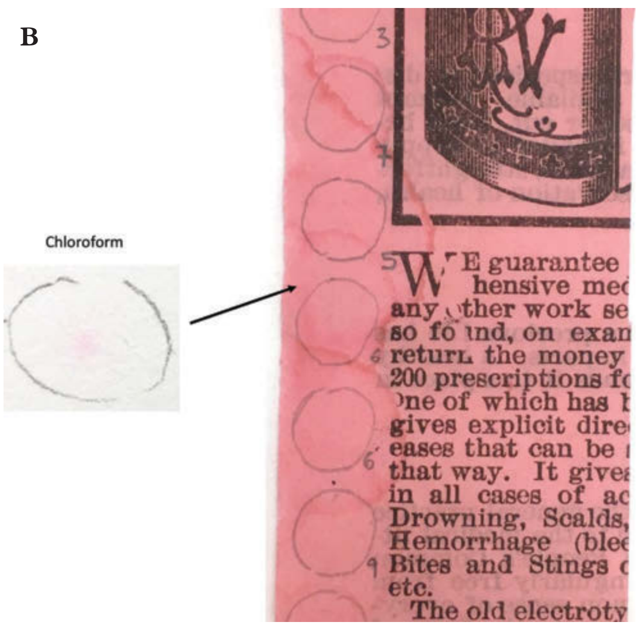


Fig. 5b. Dye bleeding of the pink sample during chloroform testing; solubilized dye captured on Whatman filter paper.

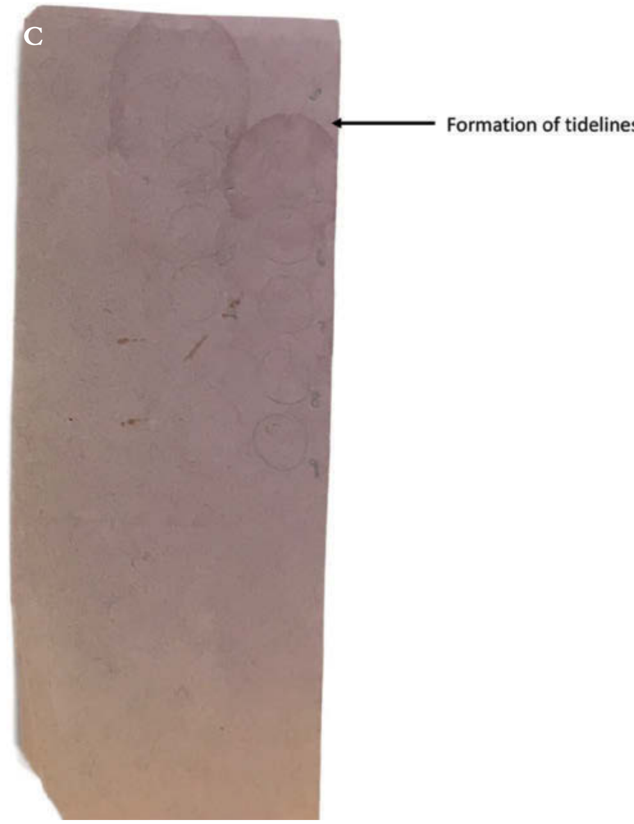


Fig. 5c. An example of tide lines on the purple sample during absorbency and dye stability tests.

Observations

Using solvent with Gellan gel did not produce good results. The solvent, when brushed on, did not penetrate the gel, resulting in its immediate release once the loaded gel was applied to the surface of the sample. There was no controlled release of the solvent. As such, this treatment was not very effective, especially for samples with carriers still attached. Severe tide lines were noted in many samples (due to the pooling of the solvent), and solubilization of the dyes occurred, causing the dyes to be absorbed into the gel matrix (figs. 8a-b). Some samples showed a visible change in color in treated areas, which was unacceptable.

This experiment showed that solvents not miscible in water could not be incorporated into the Gellan gel matrix, preventing the formation of a functional solvent gel. Other possible variations to this method could be the use of an intermediate solvent that can also bond to the water in the gel or trying different gels such as agarose or xanthan. However, Gellan gel is extremely effective for the removal of brown paper tape, requiring no manipulation of the samples, as the carrier and adhesive lift off with the gel as a single unit.

	Pink	Purple	Yellow	Plain	Green
Clear tape	Xylene	Methylene chloride	Methylene chloride	Chloroform	Toluene
Masking tape	Xylene	Xylene	Xylene	Methylene chloride	Toluene
Rubber cement	Xylene	Xylene	Xylene	Methylene chloride	Toluene

Table 3. Selected Solvents for Each Color/Adhesive Combination

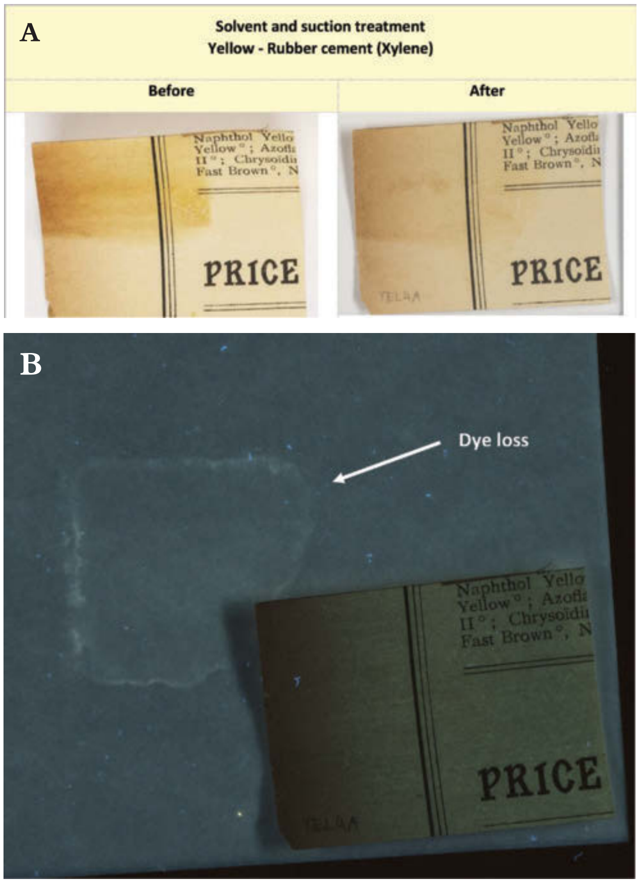


Fig. 6. (a) Before and after solvent and suction treatment images of the yellow rubber cement sample. (b) Although solvent and suction was effective, dye loss was observed and can be seen clearly under UV light.

GORE-TEX WITH SOLVENT

Technique

The Gore-Tex membrane has a pore size of 0.2 μm, allowing ultrafine particles to permeate through the membrane (Purinton and Filter 1992). Theoretically, this would allow the controlled release of solvent.[2] Initial testing confirmed that the tested solvents would not affect the Gore-Tex or the polyester to which it is bonded.

Figure 9a shows the setup for the Gore-Tex sandwich that was placed on the samples in 12-minute intervals.[3] An interleaving layer of Japanese paper was applied over the adhesive to absorb the swelled adhesive. As the adhesive swelled, the paper was removed and any remaining surface adhesive was scraped off using a spatula (fig. 9b). The Japanese interleaving and Gore-Tex were changed as needed. Excess weight should not be used in this process, as too much pressure will force the solvent through the membrane. Solvent-saturated blotter (not overly wet or dripping) was used to introduce solvent to the object.

Fig. 7. Diagram showing solvent gel setup.

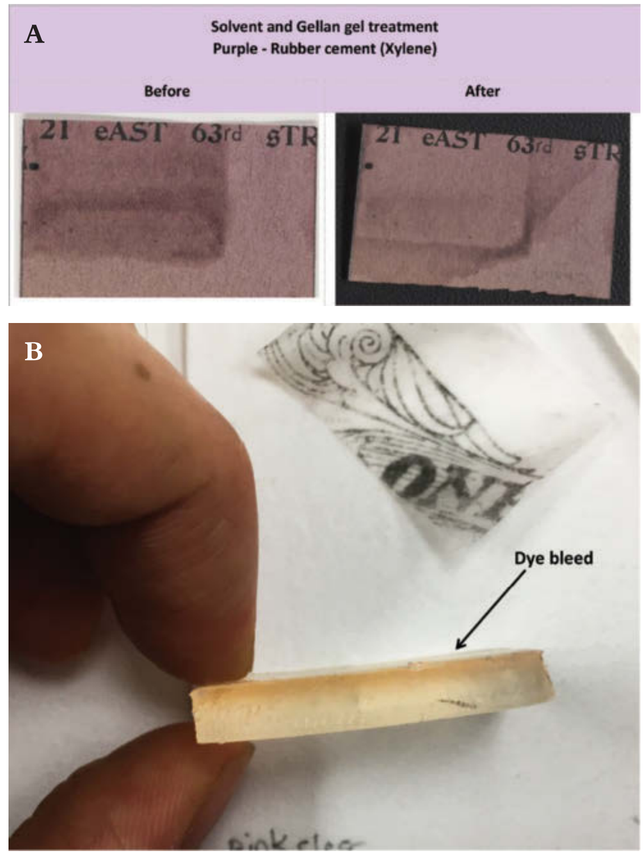


Fig. 8. (a) Before and after solvent and Gellan gel treatment images of the purple rubber cement sample. (b) Dye transfer observed in Gellan gel after treatment.

Observations

The use of Gore-Tex and solvent was an effective method for the reduction of adhesives (figs. 10a–b). Staining was reduced, and no dye bleeding and minimal tide lines (controllable) occurred. The method was effective on samples with and without carriers. Treatment times were approximately 10 to 15 applications of 12 minutes each and could go longer with a greater improvement in results.

SUMMARY OF TECHNIQUES

Figure 11 shows a summary of the three methods tested. It is important to emphasize that the goal of this research is to

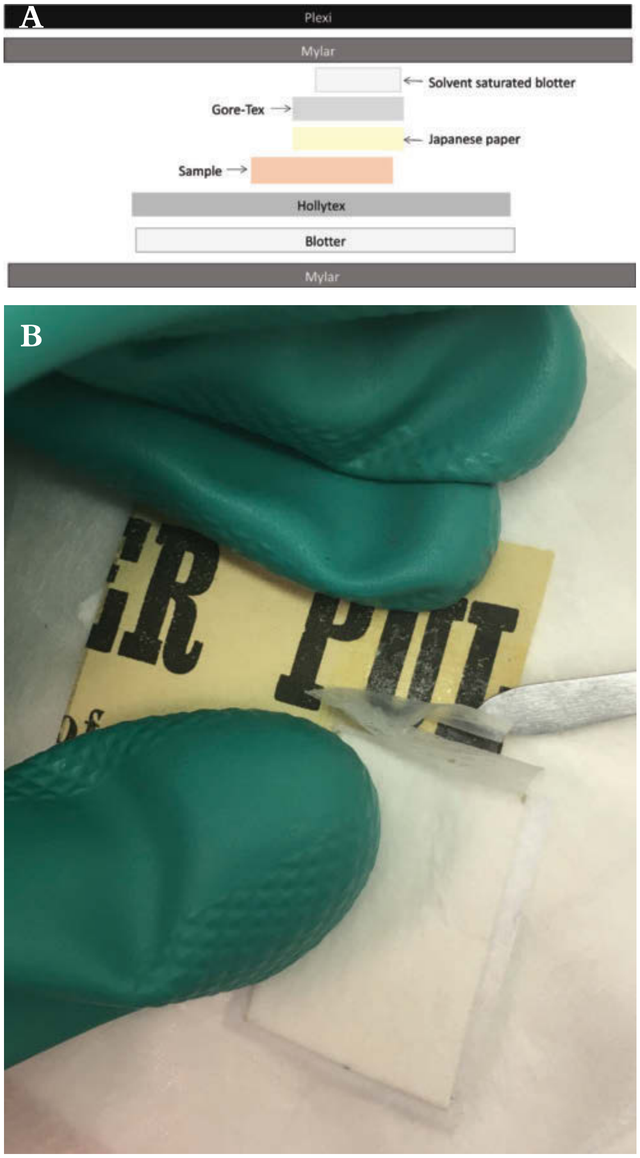


Fig. 9. (a) Diagram showing Gore-Tex setup. (b) Removing the carrier while keeping the Gore-Tex sandwich in place.

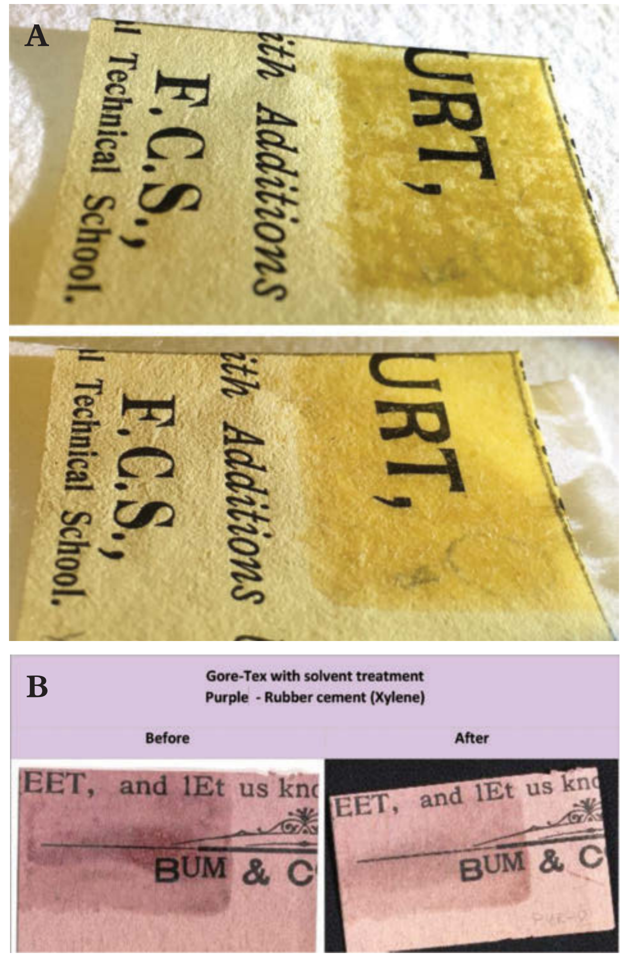


Fig. 10. (a) Visible reduction of surface adhesive on yellow masking tape after four 12-minute applications of Gore-Tex sandwich (xylene). (b) Before and after Gore-Tex and solvent treatment images of the purple rubber cement sample.

reduce the adhesive on the prints, not to reduce staining; that achievement would be considered a bonus. Due to the gentle and effective treatment provided by the Gore-Tex option, as well as the lack of dye bleeding, the methodology was adjusted to see if better results could be achieved.

Solvent and suction
- Effective adhesive removal
- Effective stain reduction
- Bleeding of dye
- Tidelines

Gellan gel and solvent
- Moderate adhesive removal
- Moderate stain reduction
- Bleeding of dye
- Severe tidelines
- Good for brown paper

Gore-Tex with solvent
- Effective adhesive removal
- Moderate stain reduction
- No dye bleed
- Minimal tidelines

Fig. 11. Summary of the techniques tested.

PERFECTING THE GORE-TEX TECHNIQUE

Techniques

A second set of samples (green) were made following the same parameters. This time, two methods were tested: the single Gore-Tex sandwich applied as described before and a double Gore-Tex sandwich applied to the recto and the verso of the samples. Interleaving paper was applied only to the recto. Application times remained at 12-minute intervals. After absorbency, dye stability tests, and adhesive removal tests, Toluene was selected as the appropriate solvent for clear tape, masking tape, and rubber cement removal on the green samples.

Single Gore-Tex Sandwich Results

The single Gore-Tex sandwich results were again extremely promising. Table 4 shows the before and after treatment images of the samples. Results were obtained after 16 to 20 (12- minute) applications. There was a marked reduction of adhesive and staining of all three adhesives. Although tide lines did form, they can be attributed to the Gore-Tex sandwiches being cut to the exact size of the treated area. As the adhesive solubilized, it spread laterally in the support. This can be avoided by cutting the Gore-Tex larger (all round) than the treated area.

Double Gore-Tex Sandwich Results

The double Gore-Tex sandwich results showed extremely effective reduction of adhesive residue and staining in the samples (table 5). Results were also achieved at a much faster rate: 8 to 16 (12-minute) applications. Once again, tide lines formed due to the size of the Gore-Tex applied, which can be reduced as mentioned earlier. Table 5 shows the before- and after-treatment images of the samples. The spectrophotometer readings of the control area and the taped area after treatment are also listed, showing the similarity in L*, a*, and b* values. Most of the readings have less than a 1.0 difference, indicating that the after-treatment areas are visibly and numerically identical to the controls.

CONCLUSION

TIME-OF-FLIGHT SECONDARY ION MASS SPECTROMETRY

TOF-SIMS was found to be an effective method for the analysis of dyes on paper. By characterizing the dyes, there was a better understanding of the sensitivities of the aniline dyes in Posada's prints—directing solvent choices for safe treatment.

CHOOSING THE SOLVENT

Less polar solvents, such as toluene, xylene, methylene chloride, and chloroform, were the solvents of choice for most dye and adhesive combinations. Table 6 shows the effectiveness of various solvents on the three tapes/adhesives from nonpolar options to more polar, without considering the dyes in the paper. The threshold limit values in parts per million are also listed to aid in making an informed solvent choice. Using this table, together with the understanding of the dye sensitivities in the paper, it is possible to get a solid starting point for choosing solvents. It is important to use appropriate personal protective equipment and ventilation when working with solvents. During this study, toluene was found to be the most effective solvent and may serve as a good starting point.

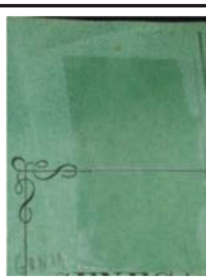
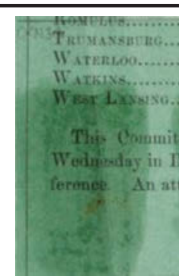
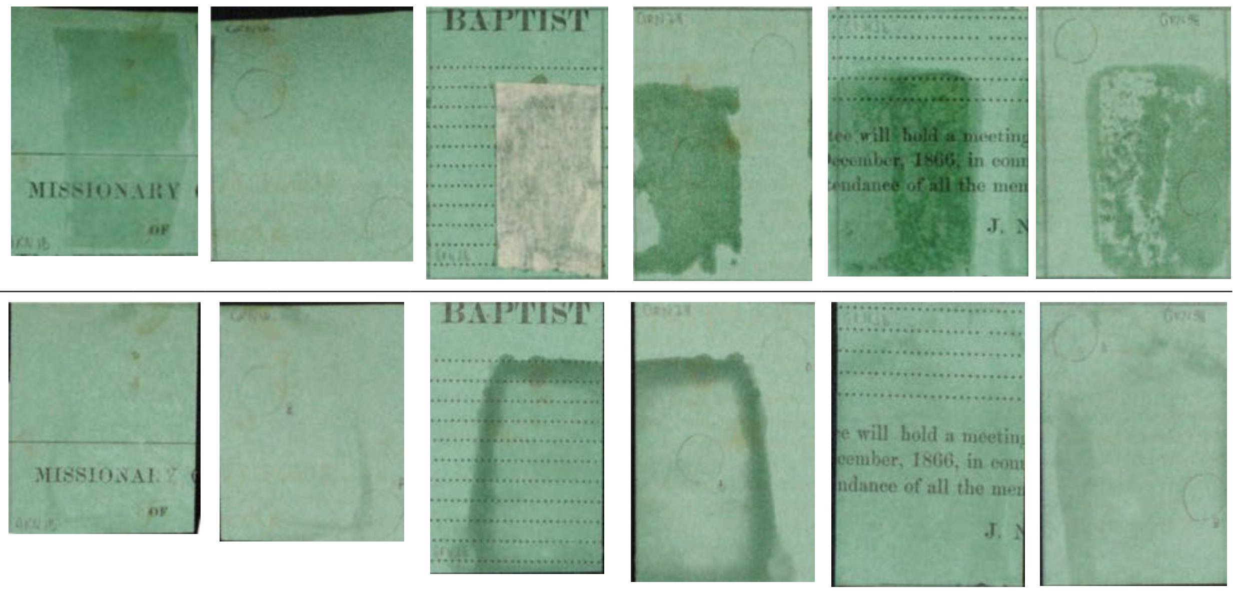
	Clear Tape (toluene)		Masking Tape (toluene)		Rubber Cement (toluene)	
	Recto	Verso	Recto	Verso	Recto	Verso
Before						
After						

Table 4. Before- and After-treatment Images of the Samples Using the Single Gore-Tex Sandwich Method

	Clear Tape (toluene)			Masking Tape (toluene)			Rubber Cement (toluene)		
	Recto		Verso	Recto		Verso	Recto		Verso



	L*	a*	b*	L*	a*	b*	L*	a*	b*
Control	66.63	–13.63	9.94	66.99	–13.93	9.62	66.99	–14.29	9.73
Tape (AT)	66.48	–13.55	10.22	64.56	–14.21	10.23	65.53	–14.38	10.08

Table 5. Before- and After-treatment Images of the Samples Using the Double Gore-Tex Sandwich Method

However, it is important to remember that absorbency and dye stability tests are paramount.

TREATMENT METHODS

Gore-Tex with solvent treatment was extremely effective. Using a double Gore-Tex sandwich achieved excellent results while decreasing treatment times. Lateral movement of the adhesive will occur, and it is recommended to cut Gore-Tex larger (all round) than the treated area. With Gore-Tex treatment, no bleeding of the dyes occurred. This leads to the idea that more polar solvents can be considered for use. Please do appropriate testing before treatment.

Unfortunately, Gore-Tex is no longer manufactured, but a comparable option is now available through Conservation-by-Design, called *Hydra Air PTFE*. It is made using the same materials but has a pore size of 2 μm. It would be worth testing with a less saturated blotter to reduce the rate of solvent transfer. Finally, this is the methodology that is being used on the Amon Carter Museum's Posada collection (fig. 12).

	Clear Tape	Masking Tape	Rubber Cement	Threshold Limit Value (ppm)
Toluene	Very effective	Very effective	Very effective	100 (N,S)
Xylene	Very effective	Very effective	Moderately effective	100 (S)
Methylene chloride	Very effective; dissolves carrier	Very effective	Moderately effective	100 (N)
Chloroform	Very effective	Very effective	Moderately effective	10 (N,C)
Acetone	Very effective; dissolves carrier	Ineffective	Moderately effective	750 (N)
Methyl ethyl ketone	Very effective; dissolves carrier	Ineffective	Moderately effective	200 (N)

Effective — Ineffective

N = Narcotic
C = Chronic
S = Skin

Table 6. Effectiveness of the Solvents on the Three Adhesives Tested

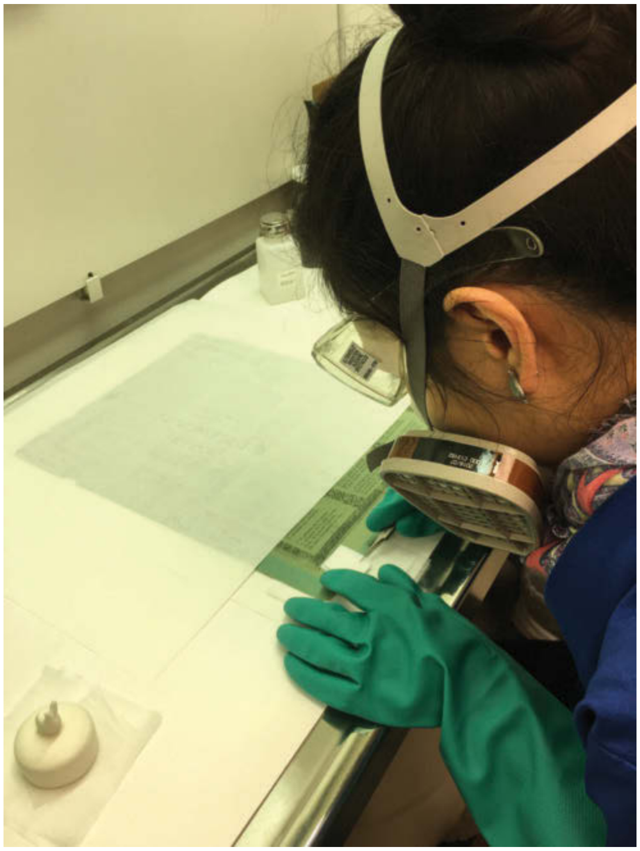


Fig. 12. Treating a Posada print in the Amon Carter Museum of American Art's collection using Gore-Tex and solvent.

ACKNOWLEDGMENTS

The authors would like to extend their gratitude to Rachel Freeman and Francesca Casadio of the Art Institute of Chicago and Gary J. Laughlin of McCrone Research Institute. Amy V. Walker, Ashley A. Ellsworth, and Jenny K. Hedlund gratefully acknowledge support from the National Science Foundation (CHE1213546). Special thanks to our colleagues at the Amon Carter Museum of American Art.

NOTES

1. Solvent gel treatment methodology was developed from research done by Vallieres (2013).
2. A study was conducted by the authors exploring the use of solvent vapor to remove masking tape adhesive from dyed paper. Two samples were placed in solvent vapor chambers (one in acetone vapor and one in ethanol vapor) and observed over time (approximately 655 hours). Using a digital microscope and TOF-SIMS analysis, it was determined that ethanol or acetone fuming successfully removed masking tape adhesive (3M 2214) from the surface of the samples (dissolved by solvent vapor) and that few other changes in the samples occurred. Ions indicative of dye remained present in all treated samples. $C_xH_y^+$ decreased after treatment, showing that dirt is also removed from the samples. This experiment gave rise to the idea of using Gore-Tex as a more practical treatment option: introducing solvent in vapor form while reducing treatment time.
3. Gore-Tex treatment methodology was developed from various techniques used by Ash (1993).

REFERENCES

Abel, M. L., and C. Coppitters. 2008. Conservation of polymers: A view to the future. *Surface Interface Analysis* 40 (3-4): 445–449.

Ash, N. 1993. The use of Gore-Tex to transmit solvent vapors in the treatment of drawings by Henry Ossawa Tanner. *AIC Book and Paper Group Annual* 12: 1-4. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v12/bp12-01.html.

Carr, C. M., R. Mitchell, and D. Howell. 2004. Surface chemical investigation into the cleaning procedures of ancient tapestry materials. Part 1. *Journal of Material Science* 39 (24): 7317–7325.

Casadio, F., K. Mauck, M. Chefitz, and R. Freeman. 2010. Direct identification of early synthetic dyes: FT-Raman study of the illustrated broadside prints of José Guadalupe Posada (1852–1913). *Applied Physics A* 100 (3): 885–899.

Erfurt, J. 1901. *The dyeing of paper pulp*. Translated by J. Hübner. London, England: Scott, Greenwood & Co.

Gillard, R. D., S. M. Hardman, R. G. Thomas, and D. E. Watkinson. 1994. The detection of dyes by FTIR microscopy. *Studies in Conservation* 39 (3): 187–192.

Guineau, B. 1989. Non-destructive analysis of organic pigments and dyes using Raman microprobe, microfluorometer or absorption microspectrophotometer. *Studies in Conservation* 34 (1): 38–44.

Kirby, J., and R. White. 1996. The identification of red lake pigment dyestuffs and a discussion of their use. *National Gallery Technical Bulletin* 17: 56–80.

Lee, Y., J. Lee, Y. Kim, S. Choi, S. W. Ham, and K. J. Kim. 2008. Investigation of natural dyes and ancient textiles from Korea using TOF-SIMS. *Applied Surface Science* 255 (4): 1033–1036.

Low, M. J. D., and N. S. Baer. 1977. Application of infrared Fourier transform spectroscopy to problems in conservation. *Studies in Conservation*, 22 (3): 116–128.

Massonnet, G., P. Buzzini, G. Jochem, M. Stauber, T. Coyle, C. Roux, J. Thomas, H. Leijenhorst, Z. Van Zanten, K. Wiggins, C. Russel, S. Chabli, and A. Rosengarten. 2005. Evaluation of Raman spectroscopy for the analysis of colored fibers: A collaborative study. *Journal of Forensic Sciences* 50 (5): 1028–1038.

Mazel, V., and P. Richardin. 2009. ToF-SIMS Study of Organic Materials in Cultural Heritage: Identification and Chemical Imaging. In *Organic Mass Spectrometry in Art* *and Archeology*, eds. M. Perla Colombini and F. Modugno. Chichester, West Sussex, UK: John Wiley & Sons. 433-457.

Mukhopadhyay, R. 2010. The art of Raman. *Chemistry World* 7: 44–47.

Purinton, N., and S. Filter. 1992. Gore-Tex: An introduction to the material and treatments. *AIC Book and Paper Group Annual* 11: 141-155.

Schweppe, H. 1987. *Practical information for the identification of early synthetic dyes: Practical hints on dyeing with early synthetic dyes*. Washington, DC: Smithsonian Institution.

Van Ham, R., L. Van Vaeck, F. Adams, and A. Adriaens. 2005. Feasibility of analyzing molecular pigments in paint layers using TOF S-SIMS. *Analytical and Bioanalytical Chemistry* 383: 991–997.

Vallieres, J. 2013. Gellan gum: Investigating applications as a solvent gel. Research project submitted to the Department of Art in conformity with the requirements for the degree of Master of Art Conservation, Queen's University, Kingston, Ontario, Canada.

Walker A. V. 2013. Secondary ion mass spectrometry. In *Elsevier reference module in chemistry, molecular sciences and chemical engineering*, ed. J. Reedijk. Waltham, MA: Elsevier.

FURTHER READING

Chen, K., M. Leona, and T. Vo-Dinh. 2007. Surface-enhanced Raman scattering for identification of organic pigments and dyes in works of art and cultural heritage material. *Sensor Review* 27 (2): 109–120.

STACEY M. KELLY
Fellow in Paper Conservation
Amon Carter Museum of American Art
Fort Worth, TX
staceymeikelly@gmail.com

JODIE UTTER
Conservator of Works on Paper
Amon Carter Museum of American Art
Fort Worth, TX
jodie.utter@cartermuseum.org

AMY V. WALKER, PhD
Professor
Department of Materials Science and Engineering
University of Texas at Dallas
Richardson, TX
amy.walker@utdallas.edu

ASHLEY A. ELLSWORTH, PhD
Department of Chemistry
University of Texas at Dallas
Richardson, TX
ashley.ellsworth@utdallas.edu

JENNY K. HEDLUND
PhD Candidate
Department of Chemistry
University of Texas at Dallas
Richardson, TX
jenny.hedlund@utdallas.edu

KARIN VAN DER PAL, SIMON W. LEWIS, WILHELM VAN BRONSWIJK, DR. RACHEL S. POPELKA-FILCOFF, AND DR. GREGORY D. SMITH

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

The contamination of paper surfaces during the process of handling documents is a significant issue for forensic scientists and conservators. In the forensic context, it has been found that polyvinyl chloride and latex gloves would leave handprints on porous and nonporous surfaces after 20 to 40 minutes of wear by a subject. Anecdotally, it has been seen by both forensic practitioners and fingerprint researchers at Curtin University that nitrile gloves can also leave fingerprints on paper after periods of wear. The issue of whether to wear gloves or not when handling documents has also been a matter of controversy in the conservation and archivist community. Prue McKay at the National Archives of Australia carried out some preliminary studies to determine the potential for contamination from gloved and non-gloved hands when handling paper items. However, other than the works mentioned earlier, there is a paucity of published research in this area. A research project has been initiated at Curtin to explore this issue by using a range of forensic fingerprint techniques to investigate the level of fingermark contamination on paper items handled with bare and covered hands. Subsequently, the effect of latent fingerprints on paper items will be investigated using artificial aging. This presentation will give an overview of the background of the methods to be used and present some of our initial results.

ACKNOWLEDGMENTS

The authors thank Terry Kent and Prue McKay for useful discussion concerning this research.

KARIN VAN DER PAL
Department of Chemistry
Curtin University
Bentley, Australia
karin.vanderpal@postgrad.curtin.edu.au

SIMON LEWIS
Department of Chemistry
Curtin University
Bentley, Australia
s.lewis@curtin.edu.au

WILHELM VAN BRONSWIJK
Department of Chemistry
Curtin University
Bentley, Australia
w.vanbronswijk@curtin.edu.au

DR. RACHEL POPELKA-FILCOFF
Department of Chemical and Physical Sciences
Flinders University
Adelaide, Australia
rachel.popelkafilcoff@flinders.edu.au

DR. GREGORY D. SMITH
Senior Conservation Scientist
Indianapolis Museum of Art
Indianapolis, IN
gdsmith@imamuseum.org

Presented at the Joint Book and Paper + Research and Technical Studies Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

The Codex Eyckensis (8th Century): Re-evaluation of the 20th Century Restoration and Conservation Treatments

The Codex Eyckensis was originally written at the scriptorium of Echternach (Luxembourg) in the 8th century and was brought to Aldeneik (northeast Belgium) by Saint Willibrord. This restrained pre-Carolingian codex is a splendid example of the dynamic confluence in the 8th century of the insular formal idiom and the artistic characteristics developing on the European mainland. After a drastic conservation treatment in 1957 with heat sealing plastic foil, the Codex Eyckensis was fully conserved in the 1990s by removing the Mipofolie lamination and reconstruction of the missing areas with parchment pulp. Since then, the manuscript was kept in the crypt of the Saint Catherine's Church, a place with a highly unstable climate. After 25 years, the need for a reassessment of the Codex Eyckensis became clear as new possibilities for in-depth research have developed considerably. In the present survey, the condition of the parchment and the stability of the leafcasting with parchment pulp was evaluated. Multispectral imaging and material technical analyses aimed to shed light on the condition and the creation of the writing and illuminations within. As part of this new survey, undertaken 25 years later, the codex has been reassessed using nondestructive analytical and imaging techniques. Able to link conservation information of the past with new data and evaluating protocols applied at the end of the 20th century will contribute to the future preservation of the Codex Eyckensis. During the campaign in the 1990s, no material technical analyses had been carried out. The combination of x-ray fluorescence spectroscopy (XRF), XRF mapping, and Raman spectroscopy has now been used to characterize the materials and inks used in the Codex Eyckensis creation. The removed Mipofolie foils have also been archived since the treatment of the early 1990s. These foils were highly adhered to the parchment, and it was not possible to remove the foils without removing some small paint fragments. These were analyzed using complementary but destructive analysis techniques aimed at the identification of organic components (binder/colorant). In addition to the analytical data, imaging also contributed to the condition evaluation and material characterization. Within the framework of the Reflectance Imaging for Cultural Heritage (RICH) project, a multispectral, multidirectional, portable, and dome-shaped acquisition system was developed to image in photometric stereo. Visualization of pigments was realized based on reflection maps. These findings were evaluated using the data obtained in a laboratory setting in addition to the data obtained through XRF, XRF mapping, and Raman spectroscopy.

The new assessment and technical study of the Codex Eyckensis reflects the complex material and conservation history of the 8th century codex. As the treatment was well documented 25 years ago, the new data is adding multiple layers of information. This research provides new insights into the origin and the creation of the illuminations and contributes to the in-depth knowledge of the oldest manuscript kept in the Low Countries of Europe. The study gives reflection to the dynamics of conservation history and the importance of ongoing data collection, revealing new challenges in technical documentation with recent imaging techniques and nondestructive analytical tools.

Presented at the Joint Book and Paper + Research and Technical Studies Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

DR. LIEVE WATTEEUW
Manuscripts and Cultural Heritage
KU Leuven
Belgium
lieve.watteeuw@kuleuven.be

MARINA VAN BOS
Scientific Researcher
Royal Institute for Cultural Heritage
Belgium
marina.vanbos@kikirpa.be

BRUNO VANDERMEULEN
ULS Digitisation and Document Delivery
KU Leuven
Belgium
bruno.vandermeulen@kuleuven.be

KARL BUCHBERG

Henri Matisse's *The Swimming Pool*: Conservation and Exhibition

ABSTRACT

The conservation of *The Swimming Pool* by Henri Matisse[1] was a multiyear project culminating in the 2014-2015 exhibition at the Museum of Modern Art, *Henri Matisse: The Cut-Outs*, and catalog of the same name. This exhibition was the first time at the museum that a conservator, the author of this paper, was also a cocurator, working with Jodi Hauptman, now senior curator for drawings and prints. This collaboration led to a new approach for the installation of cut-outs.

INTRODUCTION

During the last decade of Matisse's life, from the mid-1940s to his death in 1954, the artist turned to a new form of making art—the cut-out. The development of this technique, however, began much earlier in the artist's career. In the early 1930s, while working on *The Dance* for his American patron Alfred Barnes, Matisse realized that the laborious process of painting and wiping out paint to change compositions could be simplified by cutting and pinning sheets of painted paper to the working surface.

In 1952, as the now famous story goes, Matisse asked his assistant Lydia Delectorskaya to call a car and take him to his favorite pool in Cannes to sketch divers. When they arrived, it was so sunny that there were no swimmers, and he said, "I will die from the heat, take me home. I will make my own Pool." This is exactly what he did. Delectorskaya pinned long sheets of white Canson paper to create a frieze around the walls of the dining room at Matisse's apartment in Nice. Matisse cut swimmers and sea creatures that were pinned onto, above, and below the white frieze. The work remained on the walls of the dining room until the artist's death in late 1954 (Buchberg et al. 2014, 62-67).

In 1975, the Museum of Modern Art (MoMA) acquired *The Swimming Pool*. This work was subsequently included in the landmark Matisse cut-out exhibition of 1977 and was then consistently on view at MoMA. In 1996, curators and conservators reevaluated the condition of *The Swimming Pool*. It was decided that the altered and fragile condition of the work precluded further exposure.

MATISSE'S CUT-OUT TECHNIQUE

Matisse would visit his preferred art suppliers in both Paris and Nice and choose tubes of gouache, both for color and freshness. Large batches of gouache would be prepared by his assistants and be applied by them onto sheets of either French artists' papers or sheets cut from large rolls of paper, most often Canson and Montgolfier. Painted papers would then be dried and stored. During the early part of the cut-out phase, Matisse would work in bed, at a desk, or in a specially designed chair. For these earlier small works, he would pin the cut shapes directly onto a board. Later, when he was working on larger compositions, he would hand a cut shape to an assistant and direct her to pin the shape onto a wall of the studio. This pinning allowed for quick placement and equally quick rearrangement of both shapes and whole compositions. Period photographs of Matisse's studios in Paris, Nice, and Venice show that cut-outs pinned onto the studio walls were moved, rearranged, or removed with considerable frequency.

MOUNTING

Matisse was introduced to the firm of Lucien Lefebvre-Foinet, art suppliers and restorers, by the artist Marc Chagall, and it was in Paris that they mounted the large majority of cut-outs, both during the artist's lifetime and after his death. To transfer a cut-out from the studio to the mounters at Lefebvre-Foinet, a cut-out was unpinned from the wall and traced so that the important relationship between one cut shape and the next would be preserved exactly. The unpinning was sometimes a two-step process. The pins used to attach a cut-out to the wall would protrude too far to allow an accurate tracing. One-by-one, a pin would be removed and another would be inserted in a flat orientation, creating two holes (one going in and one coming out). Complex cut-outs were sometimes numbered on the verso of each section.

Presented at the General Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

In the Matisse dining room, *The Swimming Pool* occupied two long walls perpendicular to the left and right of the entry door and four smaller walls: two on either side of the entry door and two on either side of the window occupying the wall opposite the entry door. Together these sections total a length of 647 in.

After the death of the artist in 1954, *The Swimming Pool* was sent to Paris for mounting. At this point, the height and width of each panel needed to be decided. The four small sections were mounted to the exact width of their original dining room walls. The two long walls, however, were too long to be mounted each as one section and were therefore divided into sections: one wall into two sections and one wall into three sections. In this configuration, the final nine panels could be more easily stored, shipped, and exhibited.

Prior to the actual mounting, Madame Matisse, the widow of the artist, made two crucial decisions: the height of the panels and the fabric to be used to recreate the walls of the dining room. In documents supplied to MoMA after its acquisition of the work, Madame Matisse said that she considered the space between the ceiling and the top of the fireplace mantelpiece to be the area *The Swimming Pool* originally occupied (Buchberg et al. 2014, 62-63). Therefore, a panel height of 7 ft. 6 in. was stipulated. She also said that burlap, the wall covering of the dining room, was the only fabric honest to the original conception of the work. The mounters sourced new burlap.

CONSERVATION PROPOSAL

In the intervening 56 years between the creation of the work and the 2008 conservation proposal, each of the three elements of the work had altered: the blue cut-outs, the white paper frieze, and the burlap mount. The proposal had three goals.

COLOR BALANCE

The first was to return the work to its original color balance of blue, white, and tan. The decision to remove the burlap and replace it was the first and conceptually most simple decision. The burlap used during the 1955 mounting was not original to the dining room. It was severely altered, now a dark orange-brown and very brittle with a noticeably textured surface. A sample of the mounting burlap sent from Lefebvre-Foinet to the author's predecessor, Antoinette King, and stored in the dark showed that the burlap was originally light tan, quite supple, and smooth surfaced. In consultation with Sarah Lowengard (a private textile conservator in New York) and the staff at Testfabrics Inc., new burlap was sourced knowing that it is a material with inherent liabilities.

The white paper frieze was considerably damaged. Localized yellow-brown spots of varying size were scattered unevenly over all nine panels. It had always been assumed that the mounting adhesive had penetrated the paper and caused stains. Documents from Lefebvre-Foinet said that the mounting adhesive used for the cut-outs was a complex mixture of rye flour, wheat flour, water, animal glue, linseed oil, and Venice turpentine. Seen on many other cut-outs, it is a dark amber color. It had been assumed, incorrectly, that it was this adhesive that was used on *The Swimming Pool*. Chris McGlinchey, a conservation scientist at MoMA, analyzed the adhesive, which proved to be methyl cellulose. King had heard that an adhesive called *colle Mohican* had some role in the mounting. An Internet search provided additional information on the probable product: Mohican Teinture, La Colle Mohican, and Peinture Mohican. This information cast doubt on the theory that adhesive staining was the principal cause of the uneven discoloration. After the burlap removal was complete, stained areas were examined from both the recto and verso. Staining was not evident spot for spot on the verso, nor did the adhesive look at all discolored. The amount of moisture used in the lining process and the components within the burlap were probably the likely issues. Considerable deformation in some areas of the white frieze and uneven acid-induced decolorization in blue cut shapes mounted directly to the burlap are both physical evidence of considerable moisture during the original mounting.

The firm of Lefebvre-Foinet applied an uneven layer of white paint to the white paper support after the blue cut shapes had been mounted, as can be seen in UV-induced visible fluorescence. As this is seen in many of the cut-outs, they apparently felt that the whiteness of the paper should be preserved. Matisse's white paper supports were never painted white in his studios. In addition, discrete applications of white paint mask localized discolorations that must have occurred during the mounting process.

The next decision was whether or not to replace the white frieze that had been provided by the Parisian mounting firm and was not original. Delectorskaya, who after the death of Matisse remained one of the major experts on the cut-outs, had written to King and others that the white mounting papers could be replaced, as they did not carry the hand of the master. The only exceptions would be when Matisse actually drew, usually with charcoal, on the white ground papers. It was decided not to replace the white paper because as damaged as it was, it was almost the same age as the blue cut shapes and new paper would have been a stark contrast.

Conservation scientists at MoMA confirmed that the blue pigment in the cut shapes was ultramarine. The ultramarine, which loses color in contact with acidic conditions, had decolorized unevenly over time due to its contact with the white paper frieze and the burlap. Environmental conditions must also have played a role, as one stretcher bar in the center of a very wide panel had protected both the burlap and ultramarine from alteration.

INSTALLATION HEIGHT

The second goal was to install the work at a proper height. Photographs show the work as installed at MoMA in 1977 with a center line perhaps at chest height. Period photographs of the work confirm that the work was originally created at eye level or slightly higher. Both Pierre Matisse, representing the Matisse family, and Delectorskaya, Matisse's assistant who most likely did most of the pinning, wrote to MoMA to say that the work had been installed too low. Pierre Matisse went so far as to say that he would rather have the work deinstalled than remain at the inappropriate height.

New panels, recreating the full height of the Matisse dining room, were made for each of the nine sections. These panels allowed the cut-outs to be positioned at the proper height and also rebalanced the amount of burlap at top and bottom.

ROOM DIMENSIONS

The third goal was to design the architecture of the installation to reflect the original dimensions of the dining room at the Matisse apartment. MoMA files included a floor plan of the apartment and an elevation of the dining room. As originally installed at MoMA, one entered the room, viewed cut-out panels at left and right, and exited through a door opposite the entrance. This facilitated the flow of patrons through the galleries. The 2014-2015 installation was in a self-contained room. One entered through a door and was immersed in the cut-outs and then exited through the same door, as would have been the case during Matisse's lifetime.

It was decided early on not to adhere the cut-outs solidly onto the new burlap-covered panels. The acidity of the burlap had originally caused damage, and the author did not want to repeat this situation. It was at this point that the collaboration with Hauptman, the cocurator for the Matisse exhibition, most clearly informed the conservation protocol. Hauptman was most fascinated by the act of pinning; what was pinned could easily be unpinned. Period photographs of Matisse's studios showed that that this did indeed happen. In addition, examination of most Matisse cut-outs shows numerous pinholes, indicating the act of pinning and repinning.

It was then decided to explore the idea of pinning the work onto new burlap-covered panels. To do this, a full-scale mock-up of one of the panels was made. The result was shown to MoMA curatorial staff and members of the Matisse family. Somewhat startling at first, the idea gained traction and became the final plan. This radical installation approach returned to the work some of the three-dimensionality and liveliness that it had originally.

STORAGE

The cut-outs were pinned to the new burlap-covered panels only during exhibition. When not on view, each cut-out panel was fitted into a large drawer that slid into a custom-designed crate.

RESEARCH

In addition to visual examination of *The Swimming Pool* and scientific analysis carried out by MoMA conservation scientists, extensive archival research contributed valuable insight into exactly how the cut-outs were created.

The Archives Matisse, housed in Paris, provided written and photographic documentation, including many unpublished notes made by Delectorskaya, who had hoped to write a book on the cut-outs, as she was Matisse's chief studio manager for the entire cut-out period. Madame Matisse and Delectorskaya wrote letters to cut-out owners, MoMA included, about the cut-out technique, the mounting technique, and their thoughts on how the cut-outs should be treated in the future. The mounting firm of Lefebvre-Foinet sent King information on their techniques, and this was stored in the existing treatment files. Two of Matisse's studio assistants who were still alive were interviewed to capture their memories of working with Matisse on the cut-outs. Claude Duthuit, the artist's grandson, shared his memories of the artist.

Conservation treatment of *The Swimming Pool* at MoMA was undertaken at the same time as the Fondation Beyeler in Switzerland was treating their large cut-out, *Acanthuses*. Chief conservator Markus Gross and paper conservator Stephan Lohrengel conducted extensive research in preparation for their treatment (Buchberg et al. 2014, 253-265).

The Matisse family donated to MoMA a set of 79 painted paper samples from Matisse's studio, which demonstrates the wide range of color used by the artist. Ana Martins, a conservation scientist at MoMA, has done extensive research on this sample set. The first set of data was fadeometer testing on each sample. The light sensitivity of each sample is now known, and each sample has been analyzed for pigment and dye components. The results have been reported by Ana Martins in a separate presentation.

CONSERVATION TREATMENT

Each panel, previously stored in an individual travel frame, was placed on a large table. The tacks holding the cut-out to the stretcher were removed. The burlap/cut-out unit was lifted off the stretcher, which left the linen loose lining still attached to the stretcher. The burlap/cut-out unit was turned over and placed facedown on a clean blotter and glassine covered table. The burlap was then cut along the top and bottom edge of the back of the white frieze, and a microspatula was used to release the burlap from the paper. This created two sections of burlap for each of the nine panels. These burlaps sections were rolled and stored, partly as a document and partly as a nod to reversibility.

The removal of the burlap from the verso of the white paper was the next hurdle. The original hope was that the adhesive might have weakened enough over time to allow the burlap to be pulled back manually. This was not the case; the Canson paper delaminated with this pressure to an unacceptable degree. Moisture was then tried, but the paper was too weak to allow moisture to be used without considerable delamination of the verso. The decision was then made to remove the burlap manually. On some panels the burlap was unwoven strand by strand, and when even this was too harsh on the paper, the structure of the burlap fabric was disrupted with a Dremel rotary tool and a small spatula was used to scrape the remaining fibers. Very fine sandpaper was used to remove any remaining fibers from the verso. This removal of the burlap support was completed without introducing any moisture. The panels were then turned faceup on the table, and the white paper was surface cleaned using white vinyl erasers.

Stain reduction on the white papers was remarkably unsuccessful. Neither water nor alcohol had any appreciable effect on the staining. The use of suction had no effect. In 1977, King completed a conservation treatment on *The Swimming Pool* to reduce staining using Fuller's earth poultices with organic solvents. When this was not adequate, she bleached with hydrogen peroxide or chloramine-T. Over the years the staining returned, and it was decided not to bleach the already degraded paper.

Many of the blue shapes had been inpainted at some point in the past, and some inpainting to mask scratches was done during the previous MoMA treatment. However, the delicacy of King's treatments could not be matched with the crudeness of some areas of the extant inpainting. In the center of the very widest panel, there was extensive overpaint. Almost certainly the mounters, when confronted with a 123-in. panel, encountered difficulties and then had to mask the results. In this severely overpainted section, later gouache additions were removed, both with moisture applied with swabs and also mechanically using very fine scalpels. Stabilo CarbOthello pastel pencils were used on several panels to tone-in or tone-back individual areas.

The tacking margins at the left and right of each white paper section were reinforced with Japanese paper and wheat starch paste. New extensions, made of a Japanese paper and Tyvek sandwich, were added to each tacking margin. It is through these new extensions that the cut-outs are tacked to back of the new panels; no holes were added to the somewhat fragile original tacking margins.

MOUNTING AND INSTALLATION

New medium-density fiberboard (MDF) panels were fabricated for each of the nine cut-out sections. Each panel was built of three smaller sections bolted together on the verso. When disassembled, the smaller sections can be more easily stored. Each section was first covered with cork to provide a suitable surface for the ultimate pinning. The cork was then treated with a sealant. This was painted with a white layer to provide luminosity under the burlap. The new burlap was cut to size and adhered to the new panels.

MoMA carpenters built a room structure designed to the exact measurements of the panels, with space to support the ultimate glass glazing. The new MDF panels were placed, one by one, onto sawhorses. Each cut-out was then placed onto its custom-size burlap-covered panel. Pinning started from the center and worked toward the edges to minimize cockling. The original pinholes in the blue cut shapes were again used for the pinning. Originally, the white paper frieze would have had pin holes, but as this white paper was a replacement at the time of the 1955 mounting, no pinholes existed. The author decided that no new holes should be introduced; the number of pins through original holes was sufficient. The original tacking margins were folded around the new panels, and the Tyvek extensions were tacked to the back of the panels.

Each stainless steel pin was first soaked in acetone to ensure that any oil used in manufacture was removed. A collar of heat-shrink tubing was placed on each pin and heated into place. This collar prevented the cut-out from moving up the shaft of the pin during the months of the exhibition. After each panel was lifted into place, large glass panels were inserted to protect the gouache cut-outs during exhibition.

The treatment, from start to finish without the research component, took approximately 2000 hours.

THE EXHIBITION

The planning for this elaborate treatment was the genesis of the exhibition, *Henri Matisse: The Cut-Outs*. When the first proposal was made in 2008, *The Swimming Pool* had been off view for 15 years. Hauptman and Buchberg thought that the reinstallation of *The Swimming Pool* would be an appropriate time to mount a small exhibition. This initial idea grew to become the largest exhibition ever of Matisse cut-outs. Approximately one-half of all known cut-outs were included in the exhibition, which was a collaboration between MoMA and Tate Modern. In October 2014, the exhibition opened at MoMA—the first instance of a conservator as cocurator.

NOTE

1. *The Swimming Pool*, late summer 1952. Maquette for a ceramic (realized 1999 and 2005). Gouache on paper, cut and pasted, on painted paper, overall 185.4 cm x 1643.3 cm (73 in. x 647 in.). Installed as nine panels in two parts on burlap-covered walls. See Buchberg et al. 2014, 222.

REFERENCE

Buchberg, K., N. Cullinan, J. Hauptman, and N. Serota. 2014. *Henri Matisse: The Cut-Outs*. New York, NY: Museum of Modern Art.

FURTHER READING

Neufeld, L. 2014. Conservation of Henri Matisse's *The Swimming Pool*. Museum of Modern Art, *Inside/Out: A MoMA/MoMA PS1 Blog*. https://www.moma.org/explore/inside_out/2014/10/07/the-conservation-of-henri-matisses-the-swimming-pool/ .

KARL BUCHBERG
Former Senior Conservator
Museum of Modern Art
New York City, New York
karl.buchberg@gmail.com

REMY DREYFUSS-DESEIGNE

Nanocellulose Films: Properties, Development, and New Applications for Translucent and Transparent Artworks and Documents

ABSTRACT

This paper focuses on the use of a new and promising material in art conservation—nanocellulose film. Today, nanocellulose films are used in many fields, including medicine, electronics, and the food processing industry, as a strengthening agent with high transparency and as a biological alternative to plastic films and petroleum-derived products. After characterizing the nanoparticles obtained from cellulose, this work describes the manufacturing processes, structure, and unique properties of these new materials. The study of nanocellulose films in conservation, which began in 2014 at the scientific lab of the National Library of France (BnF, Paris, France) and is now carried out at the Research Center for Conservation (CRCC, Paris, France), focuses on microfibrillated cellulose, which is one kind of nanocellulose. The study found nanocellulose films best suited for some conservation treatments when compared to traditional repair methods. Then, nanocellulose films were applied to a range of artworks and documents made of translucent and transparent supports from several French and American museum collections.

INTRODUCTION: A JOURNEY INTO THE INFINITESIMALLY SMALL

Graphic artworks and documents made of translucent or transparent supports are omnipresent in archives, libraries, and museum collections. Thin papers, tracing papers, and cellulose acetate sheets or films are a few examples (Laroque 2003). These supports are generally delicate and fragile, and the artworks and documents can very often have some structural alterations, such as tears and weaknesses or delamination of the media, which can be a major problem for handling, consultation, digitization, or exhibition (fig. 1). In many cases, traditional repair methods are not completely adapted to solve these specific problems. The field of nanotechnologies offers new possibilities with new and innovative materials. The main objective of this study is to introduce a new material in art conservation—nanocellulose films.

Presented at the General Session, AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois

NANOCELLULOSE FILMS: CHARACTERIZATION, STRUCTURE, AND UNIQUE PROPERTIES

CHARACTERIZATION

Among nanoparticles that can be obtained from cellulose fibers, two main types can be clearly distinguished: cellulose nanocrystals (CNC) and microfibrillated cellulose (MFC). The main difference between these two materials is that MFC consists of both monocrystalline and amorphous regions of cellulose, whereas CNC is only composed of the crystalline part of cellulose, obtained by intense acid hydrolysis. The nomenclature for these materials is not yet clearly defined, and authors use various terminologies to designate the same product. In scientific literature, other terms for MFC include *cellulose microfibrils*, *cellulose nanofibrils*, *cellulose nanofibers*, and *nanocellulose*. Similarly, CNC may be termed as *whiskers, cellulose nanowhiskers*, and *nanocrystalline cellulose* (Guezennec 2012). Once they are in the form of films, these two materials could be considered as new kinds of paper, termed *nanopapers*.

STRUCTURE

MFC results from the disintegration of cellulose fibers. It is a material composed of an aggregate of cellulose microfibrils from some species of woods or plants, predelignified, obtained from layer S2 of the cell wall by intense mechanical treatments. Cellulose microfibrils are an assembly of linear glucan chains of cellulose, and the whole structure is stabilized by hydrogen bonds (Dufresne 2012; Guezennec 2012). Structurally, 100 molecules of cellulose compose 1 fundamental fibril, and 15 fundamental fibrils compose 1 microfibril. To have a better idea of the scale of these nanoparticles, the length of a microfibril is estimated to be between 1 and 3 μm, whereas the length of a fiber is generally around 1 mm (fig. 2). Additionally, the diameter of a fiber is generally estimated to be between 20 and 40 μm, whereas the diameter

Fig. 1. From left to right: Emile Reynaud, *Autour d'une cabine*, 1895: Hand-painted gelatin windows with cracks and losses (La Cinémathèque Française—Dreyfuss-Deseigne); Walt Disney Studios, *Snow White*, 1937: Animation cel (detail) with delamination of the media and weaknesses (Disney Enterprises Inc.); Louis Kahn, *FDR Memorial in NYC*, 1973: Detail of a large tear visible on the thin tracing paper (CCAHA).

of a microfibril is, similar to the length, around 1000 times smaller and estimated to be between 5 and 30 nm.

PROPERTIES

To obtain nanoparticles from cellulose, the pulp is predelignified and the hemicelluloses are removed by mechanical and enzymatic treatments to get pure cellulose (at least 95% pure). Therefore, nanocellulose films are made of pure cellulose, without lignin, and have a neutral pH, always close to 7.0. The purity of cellulose in mending materials is a stability criterion that is very important in the conservation of artworks and documents on paper. In addition, MFC films can effectively transmit light and can be as transparent as a polyester film like Mylar. Even if they are slightly visible under reflected light, they are almost invisible once they are observed with transmitted light (fig. 3). This very specific optical property is due to the origin of the microfibrils used. It is also due to the small size of the pores (more than 100 times smaller than those of a traditional sheet of paper), the size of the microfibrils (with a diameter at the nanoscale), and the important density of the structure of the films (Guezennec 2012). Concerning its tensile strength, MFC has long microfibrils that are extremely thin (with a diameter from 5 to 30 nm) and are denser than regular fibers. For these reasons, MFC film has high mechanical strength. CNC films are even more transparent than MFC films, but they have slightly less mechanical strength than MFC films, as they are only composed of the crystalline parts of cellulose.

MANUFACTURING PROCESS OF NANOCELLULOSE FILMS

MANUFACTURE OF NANOCELLULOSE

The first nanocellulose suspensions were obtained following a method developed in 1977 by researchers from the Eastern Research Division of ITT Rayonier at Whippany, New Jersey.[1] They had the idea to pass a dilute cellulose wood pulp several times through a milk homogenizer (a Manton-Gaulin 15MR

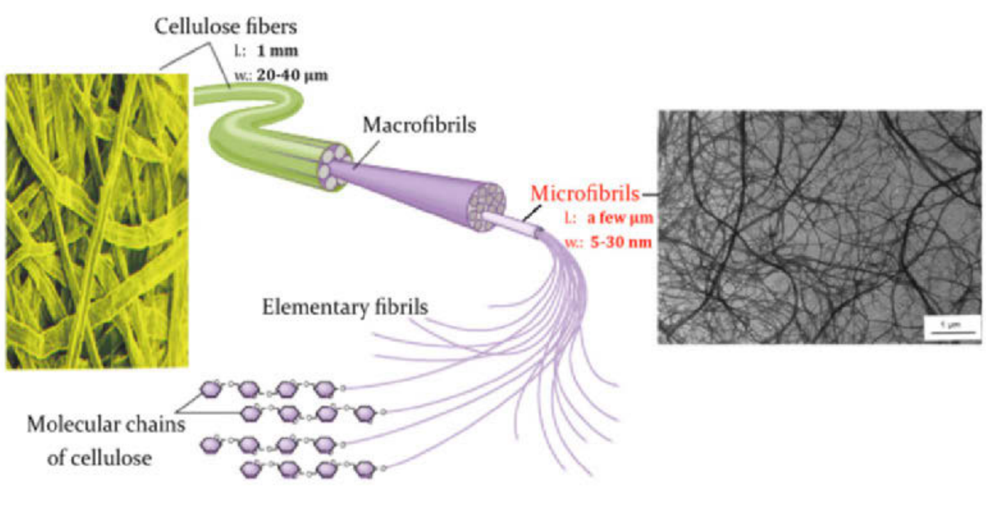


Fig. 2. Morphological structure of cellulose with the scales of fibers and microfibrils, with microfibrils observed under a TEM (Guezennec, Dreyfuss-Deseigne).

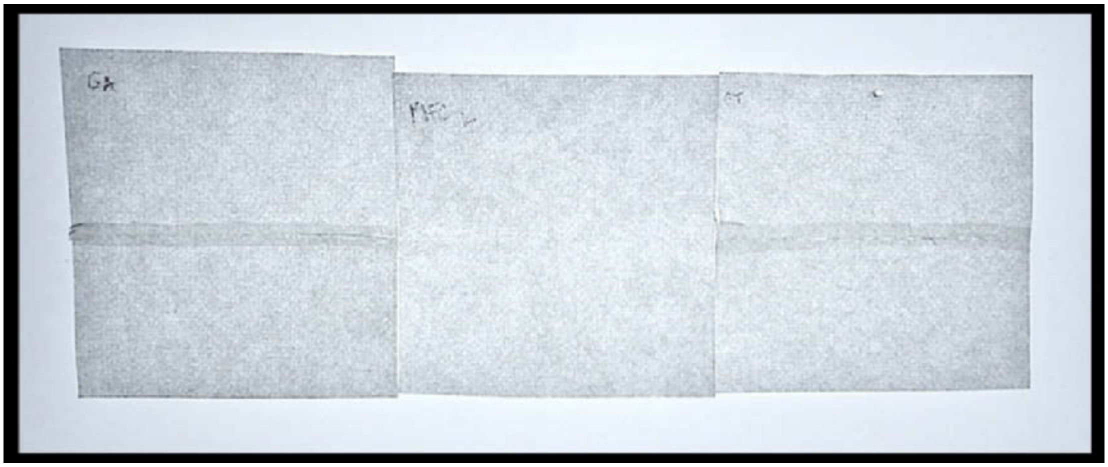


Fig. 3. Tear on a thin paper observed in transmitted light. The tear is mended with a piece of gampi 9 g/m^2 (left), a piece of kozo 8 g/m^2 (right), and a piece of MFC film (center), with the same adhesive (Klucel G in ethanol).

homogenizer), transforming fibers into a translucent gel. In fact, that mechanical treatment had broken the structure of fibers to release and obtain microfibrils. The researchers termed this new structure *microfibrillated cellulose* (MFC). Over the years, several procedures have been developed around the world for fiber delamination, where wood is always the main source used to produce MFC.

MANUFACTURE OF CELLULOSE MICROFIBRIL GEL

During this study, the author had the opportunity to visit two world major nanocellulose manufacturing facilities—the Process Development Center at the University of Maine in Orono, and the Technical Center of Paper in Grenoble, France—and to study the process closely. The method developed in 1977 consists of passing a predelignified dilute cellulose wood fiber (or paper pulp), mixed with water, several times through a mechanical homogenizer under high pressure (55 MPa) and high temperature (95°C). This important step of the process requires repeating this mechanical shearing 10 to 20 times through the double-disk refiner to extract microfibrils from fibers, increase the fibrillation, and obtain the water-based gel containing microfibrils (fig. 4). Some pretreatments of the pulp (mechanical, enzymatic, or chemical actions) are generally done to facilitate the disintegration of cellulose.

MANUFACTURE OF NANOCELLULOSE FILMS

MFC films are made from a water-based gel containing cellulose microfibrils. There are three methods for making MFC films (Guezennec 2012): (1) handsheet using a lab form, (2) filtration, and (3) casting-evaporation. The Technical Center of Paper graciously gave the author three types of 2% cellulose microfibrils from different species of trees or plants: birch kraft, spruce, and cotton. After making many MFC films, an optimal film was selected. Made of birch kraft microfibrils, the optimal film showed the necessary characteristics for conservation treatment: transparency, absence of coloration,

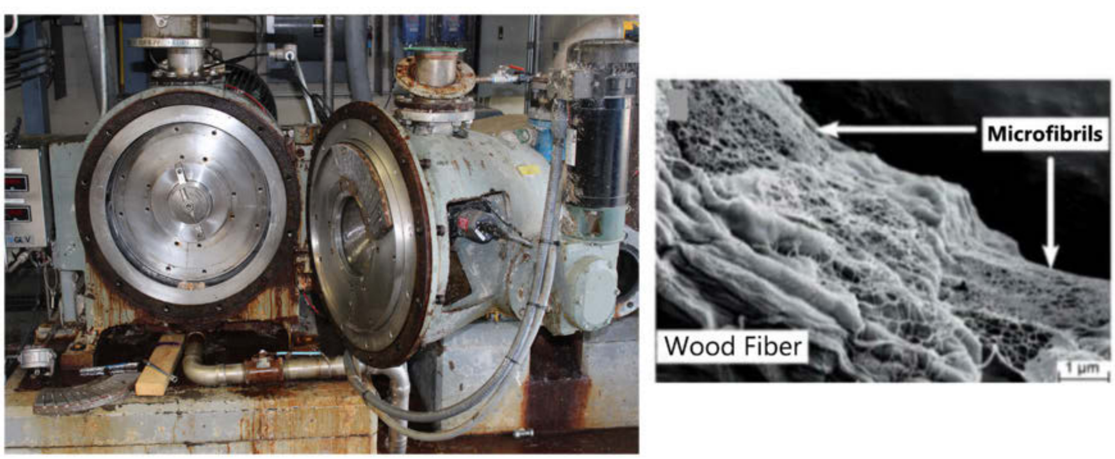


Fig. 4. Double-disk refiner at the Process Development Center at the University of Maine and microfibrils obtained from fibers.

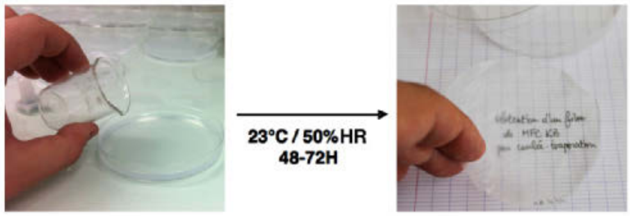


Fig. 5. Making a thin and homogeneous MFC film with the casting-evaporation technique.

homogeneity, and flexibility. After doing some tests, the casting-evaporation method of manufacture was selected due to the regularity and homogeneity of the produced films. The process was easy to reproduce, with a high yield, in a conservation lab. To make a thin film (with a thickness between 8 and 20 μm) using the casting-evaporation method, 10 g of the gel was mixed with 100 mL of deionized water to obtain a homogeneous suspension. Next, 20 mL of the suspension was poured into 90-mm polystyrene petri dishes. After 2 to 3 days of drying in a controlled environment (23°C; 50%RH), the water had evaporated and a homogeneous MFC film had formed[2] (fig. 5). These nanopapers are not dangerous to health, as they are already formed sheets, not in the form of powder or spray, and therefore its nanoparticles cannot be inhaled.

APPLICATION OF NANOCELLULOSE FILMS IN CONSERVATION

Results of tests show that MFC film has very good stability to light, temperature, and humidity aging (Dreyfuss-Deseigne 2017b). Its unique properties of transparency don't change with light, temperature and humidity aging. Additionally, a MFC film can be very thin but stronger than the thin Japanese papers generally used in paper conservation to mend translucent artworks and documents (gampi or kozo). MFC and CNC films are more sensitive to direct application of water than paper and will shrink, but they stay flat with high temperature and humidity variations. Once applied to a piece of paper with an ethanol-based adhesive, the film can be easily removed without leaving any residue behind. Considering these results, it is clear that nanocellulose films can be very suitable for mending paper objects made of translucent or transparent supports. These new materials were used for the first time during some treatments listed hereinafter.

MENDING THIN PAPER OBJECTS AND TRACING PAPERS

The first application of nanocellulose films on museum objects was performed on a series of viewing slides from the mid-19th century belonging to the French Museum of Cinema (La Cinémathèque Française). These objects were originally inserted through a show box to be able to watch them under reflected and transmitted light to create daytime, nighttime, and changing scenery effects (Mannoni 1996). These objects are made of two sheets of thin translucent papers. Most of these slides had large tears, which weakened the structure and interfered with the legibility of the images. The main goal of conservation treatment was to increase legibility of the damaged viewing slides under both reflected and transmitted light. Additionally, it was important to respect the process of the inventor and his choice of the transparency of the materials that were used to make the slides. The new conservation method used to treat these objects has been detailed in another publication (Dreyfuss-Deseigne 2017b). Large tears were mended using strips of MFC film and 5% Klucel G in ethanol, and treatment was regularly done on a light table (Stanley 1996) (fig. 6).

Fig. 6. Strips of MFC film are cut and pasted with Klucel G in ethanol (left) to mend large tears on the verso of the viewing slide (center). Viewing slide in transmitted light before and after mending (right).

Fig. 7. Pierre-Henri Amand-Lefort, *Viewing slide of Oxford,* 1850, 14.5 x 20 cm. Reflected light (left) and transmitted light (right), before and after treatment. (La Cinémathèque Française—Dreyfuss-Deseigne)

The results of these treatments are visible in figure 7, which shows a viewing slide in reflected light (left) and in transmitted light (right), before and after treatment with strips of nanocellulose film.[3]

Using the same method, strips of MFC film were used to mend an architectural drawing on tracing paper by the architect Louis Kahn belonging to Architectural Archives of the University of Pennsylvania in Philadelphia. The large tear on this tracing paper was mended using strips of MFC film and a 5% Klucel G in ethanol (fig. 8).

MENDING GELATIN WINDOWS

Some of the viewing slides belonging to the French Museum of Cinema have gelatin windows at the verso that were used to increase the visual effects while the slides were viewed under transmitted light. But some of these gelatin windows had large cracks, which were consolidated using strips of MFC films. The results are visible in figure 9.

CONSOLIDATION OF ANIMATION CELS

Nanocellulose films were also used in the conservation treatment of animation cels that had been used for production of the cartoon *Jeannot l'intrépide* from the animation director Jean Image in the 1950s, from the French National Center of Cinematography (Centre National de la Cinématographie). These objects are hand painted on transparent sheets of cellulose acetate. A major and recurrent problem of these objects is delamination of the media after aging of the cellulose acetate sheet. Some tests were performed to consolidate the media. CNC film was selected for this treatment, as this material is as transparent as the cellulose acetate sheet, and the same method of application described with MFC film was used. As is visible in figure 10, some fragments of the media were readhered to the support using strips of CNC films and Aquazol 200. This method also gives a new support to the paint in these treated areas.

CONCLUSION: NEW AND PROMISING MATERIALS FOR CONSERVATION PROFESSIONALS

The field of nanotechnology offers many new possibilities to the field of art conservation. Nanotechnologies allow conservators to work with new materials offering unique and innovative properties and to acquire new methods with many advantages. The use of nanocellulose film already proved to be the most effective solution for some specific problems experienced with museum objects. This study was an opportunity to gather new information about the material, such as its reaction to different aging tests and its behavior while combined with adhesives generally used in paper conservation.

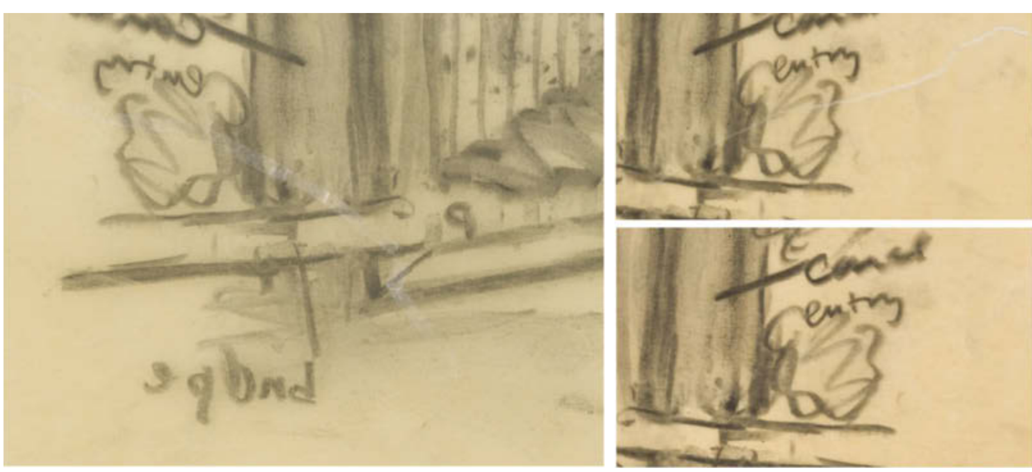


Fig. 8. Louis Kahn, *FDR Memorial in NYC*, 1973, charcoal on tracing paper, 30 x 43 cm, University of Pennsylvania Architectural Archives. Detail of a large tear mended on the verso with strips of MFC film (left) and detail of the recto before and after treatment (right). (CCAHA)

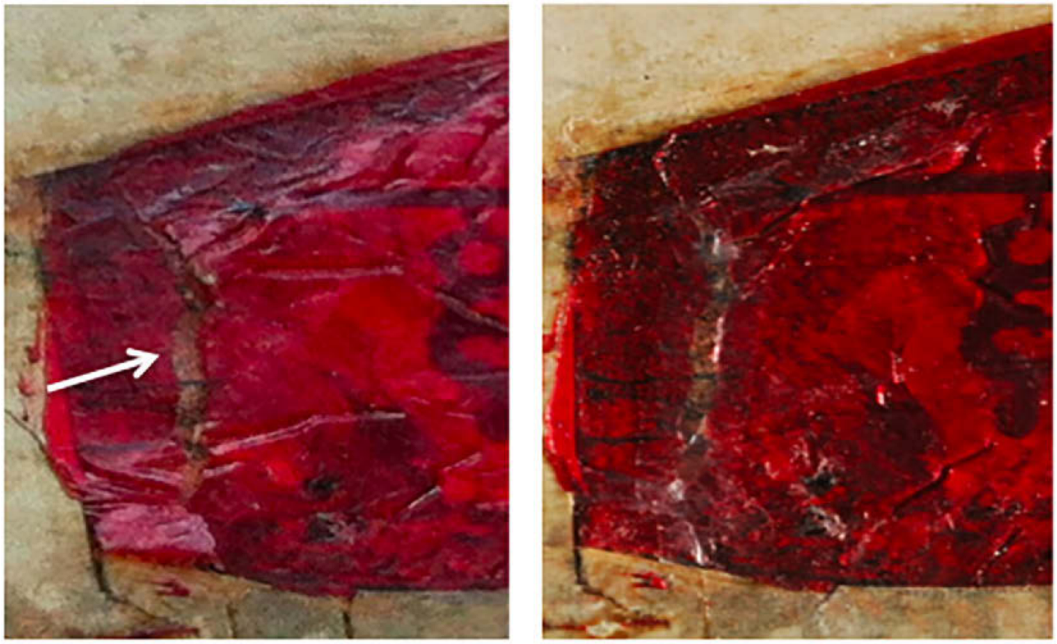


Fig. 9. Gelatin window visible on the verso of one of the viewing slides from the series with a large crack (left) and consolidated with strips of MFC film (right). (La Cinémathèque Française—Dreyfuss-Deseigne)

After having used this material for the first time on museum objects, it is now clear that nanocellulose film is a very promising material. MFC film could be a perfect solution to other problems visible on a wide range of media, such as graphic, photographic, and cinematographic artworks and documents, old or contemporary, made of translucent or transparent supports. The use of nanocellulose films in the field of paper or film conservation today is a fairly new field of investigation. A new research project is currently being carried out at the Research Center for Conservation (CRCC, Paris, France) to further characterize these materials and to study their new possible applications in art conservation. It entails a partnership with American and French nanocellulose manufacturing laboratories, the French Museum of Cinema, and the French National Center of Cinematography. The study is also a good opportunity to work closely with some nanocellulose manufacturers to develop these new and promising materials specifically for conservation professionals.

ACKNOWLEDGMENTS

I would like to thank the following people and institutions: Bertrand Lavedrine and Anne-Laurence Dupont from the Research Center for Conservation (CRCC, Paris, France); Françoise Lemerige and Laurent Mannoni from the French Museum of Cinema (La Cinemathèque Française, Paris, France); Jean-Baptiste Garnero and Anne-Laure Soulie from the National Center of Cinematography (CNC, Bois d'Arcy, France); Valerie Lee at the INP Conservation Program (Paris, France); Stephane Bouvet and Emilie Le-Bourg from the

Fig. 10. Jean Image, *Jeannot l'intrépide*, 1950, ink and gouache on cellulose acetate, French National Center for Cinematography, Tetras Quebec Inc. Detail showing delamination of the media (left) and consolidation with strips of CNC films (center and right). (CNC—Dreyfuss-Deseigne)

Scientific Lab of the National Library of France (BnF, Bussy-Saint-Georges, France); Alain Dufresne, David Guérin, and Michel Petit-Conil from the Technical Center of Paper (CTP, Grenoble, France); Michael Bilodeau from the University of Maine-Orono; Ted Stanley from the Firestone Library (Princeton, NJ); my colleagues and friends at CCAHA (Philadelphia, PA), with special thanks to Mary Schobert and Jessica Silverman; my colleagues and friends at the Harry Ransom Center (Austin, TX); and Sophie Rossato at INP (Paris, France). This work is dedicated to my parents.

NOTES

1. This method, invented and developed by Albin F. Turbak, Fred W. Snyder, and Karen R. Sandberd, is presented in US Patent 4378381A: *Suspensions containing microfibrillated cellulose* (published October 1980; registered March 1983).
2. During the drying of the MFC solution under temperature and humidity control, it is advised to put a lid on the petri dish, covering part of it, to make a very homogeneous film and to avoid any dispersion of the microfibrils in suspension. The use of deionized water also avoids any lime scale residues at the surface of the film once dried.
3. Mending viewing slides with large tears required the removal of the secondary support to gain access to the verso of the primary support. Removal was undertaken following a technique described by Ted Stanley, senior paper conservator at the Firestone Library of Princeton University, who worked on similar objects in the 1990s (Stanley 1996). The secondary support was removed from the primary using pieces of blotters dampened with deionized water heated with a tacking iron through a piece of nonwoven polyester. After removal, the two sheets (the primary and the secondary supports) were treated independently and mended with strips of MFC film. The two supports were then realigned again, following the exact original alignment.

REFERENCES

Dreyfuss-Deseigne, R. 2015. La magie du papier mise en lumière: Conservation-Restauration d'une série de 12 vues de polyorama panoptique, vers 1850 (Paris, Cinémathèque Française); Recherche sur la transparence des matériaux de consolidation du papier en lumière transmise: Introduction de la nanocellulose en conservation-restauration. Master's thesis, Institut National du Patrimoine, Paris, France.

Dreyfuss-Deseigne, R. 2016. Research on the transparency of mending in transmitted light: Introduction of nanocellulose in paper conservation. Paper presented at the ICOM-CC Graphic Documents Working Group Interim Meeting, Paris, France.

Dreyfuss-Deseigne, R. 2017a. La nanocellulose en conservation-restauration: Première application de ce nouveau matériau prometteur pour la consolidation des œuvres graphiques à caractère translucide et transparent. *Support/Tracé* 16: 75-83.

Dreyfuss-Deseigne, R. 2017b. Nanocellulose films in art conservation: *Journal of Paper Conservation* 18 (1): 18-29, 36-37.

Dufresne, A. 2012. *Nanocellulose: From nature to high performance tailored materials*. Berlin, Germany: Walter de Gruyter & Co.

Guezennec, C. 2012. Development of new packing materials based on micro- and nano-fibrillated cellulose. Ph.D. diss., Laboratoire du Génie des Procédés Papetiers, Grenoble, France.

Laroque, C. 2003. Les papiers transparents dans les collections patrimoniales: Composition, fabrication, dégradation, conservation (Transparent papers in cultural heritage collections: Composition, making processes, degradation, conservation). Ph.D. diss., University Paris I Panthéon-Sorbonne, Paris, France.

Mannoni, L. 1996. *Trois siècles de cinéma: De la lanterne magique au cinématographe (Three centuries of cinema: From the magic lantern to the cinematograph)*. Paris, France: RMN, Réunion des Musées Nationaux.

Stanley, T. 1996. A conservation case study of polyorama panoptique paper viewing slides. *Journal of the American Institute for Conservation* 35 (2): 79-98.

REMY DREYFUSS-DESEIGNE
Paper Conservator and Researcher
Paris, France
remy.dreyfuss@gmail.com
http://www.napanoper.com

RACHEL FREEMAN, CYNTIA KARNES, AND HARRIET K. STRATIS
DISCUSSION GROUP CO-CHAIRS

Art on Paper Discussion Group 2017 Multiple Perspectives on the Treatment of Multiples: Innovative Thinking on the Conservation of Prints

INTRODUCTION

Prints, which are often produced in large numbers, present challenges for the conservator who seeks to treat them. Treatment of prints takes two forms: most often it is undertaken with the print in isolation from the rest of an edition; less frequently, the conservator has the opportunity to treat an entire group of prints that is issued as part of a portfolio. Prints from an edition may be pristine, whereas others may evince various degrees of damage since some examples may be safeguarded by storage within the folds of a portfolio never to see the light of day, or the prints may be significantly altered by long-term display, poor storage conditions, or previous restoration. Furthermore, once an edition or series is dispersed, the condition of individual exemplars can span the gamut from pristine to severely damaged.

To address these issues, Judith Walsh, Sarah Bertalan, and Anisha Gupta presented the experiences, reactions, or observations that they have made over time, and that have influenced how they approach working with prints. Each speaker explored the complex considerations given to the conservation and display of multiples and emphasized how the treatment of a print is shaped not only by its context within an edition or a portfolio but also by the sometimes divergent expectations of curators and collectors for display among related works. Walsh's talk focused on how she approached the treatment of a single isolated example from a group of multiples, faced with the fact that the work appears far different today than it did when first printed by the artist. Bertalan addressed how we as conservators may add clarity to an artist's intent or surmise the original appearance of a print by looking at the papers used in 19th and 20th century printmaking side by side in comparison to related works. Gupta presented her approach to treatment of a group of prints that could be challenging because one or more prints in the group do not look the same, although they were originally intended to match by the artist. She asked might there be an implied imperative to unify the appearance of works that were intended to be viewed in a series?

As noted in the session's title, for our purposes the term *multiples* comprises duplicate impressions of an edition print, or prints issued as a group, created by the same printer at a particular time and place. The materials are often the same, and we assume that the individual works were almost indistinguishable at the time of their manufacture. We also talk about a print's "cohort." *Cohort* is a term from statistics that refers to a group of subjects with a common defining characteristic, usually age. This is a useful concept for conservators because the materials used in works from the same era and culture can be expected to be similar.

Both multiples and items within a cohort are useful to us as we design treatment and determine desired outcome. Unlike duplicate copies of a particular print that tend to be dispersed, items in a cohort are more likely to be available to us for consultation. But there are limits to the usefulness of these comparable items. Importantly, we can rely on our own practical experience of similar objects for comparison, on the experience of colleagues, and on published conservation information on the treatment or study of similar of items.

PRESENTATION SUMMARIES

JUDITH WALSH

SINGULAR PROBLEMS IN SIMILAR PRINTS: THE TREATMENT OF THREE 15TH CENTURY ENGRAVINGS

In the opening presentation, Walsh shared her insights on the treatment of three old master prints that she undertook as a senior paper conservator at the National Gallery of Art (NGA) in Washington, DC. Although not "multiples" per

This open discussion took place on June 1, 2017, during AIC's 45th Annual Meeting, May 28–June 2, 2017, Chicago, Illinois. The moderators organized and led the discussion and recorded notes. Readers are reminded that the moderators do not necessarily endorse all 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.

se, the prints formed a physical cohort based on material and execution: all three were copperplate engravings made in Europe within a 15-year period between 1465 and ca. 1480. And although their physical condition had diverged over the course of 550 years, it had also accrued meaning through research and interpretation that needed to be considered in treatment. Given the rarity of these surviving impressions, it was clear that a worldwide audience of experts would be aware of each print's particular history and its place within current research. Scholars would certainly have opinions about any treatment, and for some their stake in this was personal, having already published judgments on prints in the condition in which they were acquired. Curatorial reverence for published scholarship, which documents a print's condition in images and descriptive prose, was put forward as an important concern. Walsh relied heavily upon the NGA's curator to articulate the requirements imposed by scholarship as treatment goals were decided. She underscored the critical importance of the curatorial-conservation partnership for a successful treatment outcome by making sure that she understood the curatorial enterprise of relying on visual memory to rank prints among multiples, and by clearly communicating expectations for treatment to the curator.

The three prints exhibited similar damages related to age, misuse, and poor storage. *Saint Michael Defeating the Devils* (fig. 1), by The Master E.S. (1420–1468), sustained a particularly large loss to the image, whereas *Man in a Fantastic Helmet* (fig. 2), by an unknown Florentine artist (15th century), and *The Virgin and Child* (fig. 3), by Andrea Mantegna (1431–1506), had previous interventions that would need to be reversed before any subsequent treatment would effect a change in their condition.

Man in a Fantastic Helmet is a small print, about 3 × 5 in., which had at some point been repaired and mounted to a stiff paper card, later trimmed. Losses in the sheet had been patched from behind and inpainted, rather inexpertly, with watercolor. One large loss in the backside of the putto had been filled with a fragment from an engraving. The surface had been scuffed and abraded, which, along with the losses, contributed to the "visual noise" that interfered with the legibility of the print.

The Virgin and Child by Mantegna was mounted overall to paperboard, which secured a long gray tear extending through the background and into the faces of the Madonna and child. At some point, the corners had been clipped and then filled with paper of a similar tone and texture. Walsh considered such damage disfiguring since the prints did not at all resemble others in their cohort held in museum collections.

But in fact, the material condition represented in each of these prints had acquired important meaning during their long history. The Master E.S. print, originally one of a large edition of multiples, was now only one of five impressions known in the world, and the last held in private hands. Moreover, it

Fig. 1. Master E.S., German, active ca. 1450–1467, *Saint Michael Defeating the Devils*, 1467, engraving on laid paper, sheet (trimmed to plate mark): 17.6 × 13.3 cm. National Gallery of Art, Washington, DC, Gift of The Artemis Group, 1997.89.5. Before treatment.

had been described and published in its current state ca. 1910 by Max Lehrs, the great chronicler of 15th century prints (Lehrs 1970). Known as the "Oettingen-Wallerstein" impression, it had been seen and studied in this condition by at least three generations of old master print curators. For the current curator, the *tradition* of its condition, rather than its original condition alone, became the important factor in establishing goals for treatment. In other words, the curator insisted that the present appearance be privileged over the original appearance.

The Mantegna print was likewise only one of five extant first state impressions and the last in a private collection. Furthermore, recent scholarship on Mantegna prints by Shelley Fletcher, then head of Paper Conservation at the NGA, had shown that two of the five first state impressions of this very print, held in important collections around the world, were not as they seemed: in fact, she showed through careful photographic documentation that many Mantegna prints were heavily overpainted or reworked by hand to enhance the engraved lines (Fletcher 1970). This caused a worldwide reevaluation of the ranking of impressions. This recent scholarship also meant that any work on the Mantegna print would be scrutinized, and certainly any inpainting of losses in the engraved lines would be roundly criticized by curators.

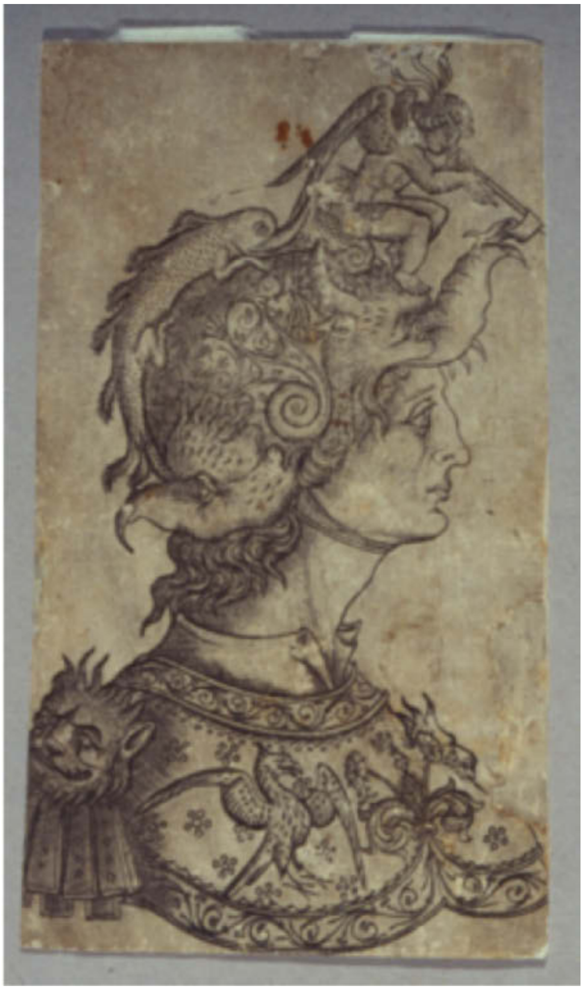


Fig. 2. Italian 15th century, *Man in a Fantastic Helmet,* ca. 1470–1480, engraving, sheet: 12.8 × 7.5 cm. National Gallery of Art, Washington, DC, Rosenwald Collection, 1943.3.9069. Before treatment.

Man in a Fantastic Helmet is a unique image—it is the only surviving copy of the many that were surely printed in Florence in the 1470s. Its imagery connected it to the studio or artists around Verrocchio, although the artist has not yet been identified (Rubin and Wright 1999). It had been studied in this condition by generations of scholars. The current curator worried that the existing repairs might contribute to a future attribution, one that might connect it to one of the best artists around Verrocchio—perhaps even to Leonardo da Vinci. Walsh also noted that the curator seemed concerned that any changes to its appearance might dismay curators who had just published it, or that the NGA would be criticized for imposing changes to the print.

Eventually, through discussion and negotiation, the curator and conservator agreed that treatment would benefit each of the prints by making them more legible to both scholars and visitors to the museum, and could be undertaken as long as honest concerns about their curatorial history were respected.

Fig. 3. Andrea Mantegna, Paduan, ca. 1431–1506, *The Virgin and Child,* 1470s (?) engraving on laid paper, sheet (trimmed within plate mark): 27.7 × 23.1 cm. National Gallery of Art, Washington, DC, Patrons' Permanent Fund, 1998.50.1. Before treatment.

Given the increased scrutiny of the Mantegna print, the treatment proposal did not include any cosmetic compensation for losses. In addition to the long, dirty, misaligned tear noted earlier, and gray accretions in the upper right, there were areas of abrasion and old creases that were slightly lighter in tone than the rest of the sheet. Ideally, the flaws would be ameliorated by treatment, without the inclusion of any inpainting. To begin, the print was surface cleaned, wet out, and turned facedown on a light box to remove the backing. Tears were secured without adhesive by flowing liquid paper pulp from the reverse, under and over the grayed edges that had contributed to its disfigurement. Any pulp on engraved lines was removed when dry, with a needle under magnification. Since the print was only wet out and blotted, not bathed, the discoloration inherent to old papers was only subtly reduced and redistributed, thereby improving the visibility of abraded areas without drastically altering the paper color. Gray pigment stains were made less prominent by rolling over the surface with a cotton swab to remove old retouching and to deposit a fine layer of liquid paper pulp on top. The layer of pulp blended with the surrounding paper, disguising the stain in a completely reversible way without removing it through treatment or added inpainting (fig. 4).

Fig. 4. Andrea Mantegna, *The Virgin and Child,* 1470s (?). National Gallery of Art 1998.50.1. After treatment detail.

Fig. 5. Italian 15th century, *Man in a Fantastic Helmet*, ca. 1470–1480. National Gallery of Art 1943.3.9069. After treatment.

Treatment of *Man in a Fantastic Helmet* likewise required removal from a secondary support, along with removal of the old paper repairs. The secondary support and repairs were saved in the curatorial file for future research. As before, the print was wet out and blotted, and losses were filled on the reverse with paper pulp. Before proceeding with any further treatment, the curator considered what compensation might be acceptable. Walsh informally solicited suggestions from colleagues about possible reconstruction of the image until the curator was ready to discuss options. Over several meetings, each fill was considered separately, and all compensation for design on the pulp fills was considered line by line, detailing exactly what the print would look like after treatment (fig. 5).

The *Saint Michael* print, also wetted out, blotted, and repaired with paper pulp, was allowed to dry in its intermediate state before considering how best to compensate for the large image loss in the corner. After comparing the print to its cohort in the NGA, and examination of two impressions in Dresden and Berlin, Walsh decided to fabricate two removable inserts for the loss. The two interchangeable repairs allow the print to be viewed in an unrepaired state without any fill, or in a repaired state with complete compensation of the printed design. Walsh used a collotype reproduction of the Dresden impression to create a suitable insert. After scanning the reproduction, she printed the image onto clear plastic, adjusting the dimensions in Adobe Photoshop until it matched the exact dimensions of the print. The area of loss was digitally segregated from the rest before printing at 60% gray onto a vintage laid paper. This produced a faint outline of the lost design, which Walsh reinforced by working under the microscope with a fine-point Rapidograph pen and Rapidograph ink she had mixed to match the original. The repair was then trimmed and toned with watercolor and pastel to match the print.

The large chamfered edges in the loss carried vestiges of the printing that were not to be covered, so Walsh mounted the insert to a shaped piece of mat board that fit securely into a hole cut into the backing board of the mat (fig. 6). The edges of the insert fit on top of the chamfered edges of the loss to visualize the seamless continuation of the engraved lines without a permanent attachment. Another fill, consisting only of a shaped piece of antique paper, was similarly mounted onto mat board, although the edges fit *under* the chamfer of the loss to leave the vestiges of printing visible (fig. 7). Each repair acted as a puzzle piece that could be popped into holes cut in the mat as the curator wished. This solution allowed the print to be seen in two “formats” without compromising the evidentiary value of the print’s

Fig. 6. Master E.S., *Saint Michael Defeating the Devils*, 1467. National Gallery of Art 1997.89.5. During treatment, showing puzzle-piece method of attachment to mat board.

damaged condition. Although initially resistant, the curator was pleased to have the option to visualize the work in a fully restored state, and it is this view that was chosen to be shown on the NGA website (fig. 8).

As she reflected on her treatments, Walsh noted that at the time she had not thought of the prints as a related group, but realized later that thinking about them together illustrates a process that all conservators go through to make subjective decisions about treatment. Both condition and context are critically important, and balancing these factors, making judgments about them, and communicating our expertise to devise individualized, subjective solutions is the essence of our job as conservators.

Judith Walsh, Williamstown Regional Art Conservation Center, Member, Board of Trustees; formerly Professor of Paper Conservation, Art Conservation Department, Buffalo State College

SARAH BERTALAN

EDITIONS AND TREATMENT: VAN GELDER ZONEN, ARCHES, RIVES, MONTVAL, MBM, …

Bertalan discussed how the experience of treatment may be enriched when one treats multiples. She showed highlights of late 19th and 20th century multiples, examined and treated over the past 20 years, to illustrate that paper conservators can learn a great deal about how papers age when multiples are compared in a focused and systematic way, that the types of damage observed in papers made for printmaking "evolved" during this period, and that the experience of treating very similar papers or multiples influences treatment decisions and treating multiples allows conservators to examine and critique standards of treatment.

In the 19th century, the European paper used for lithographs was notoriously poor in quality. This paper was available to artists in the generations of Henri de Toulouse-Lautrec (1864–1901) and Édouard Manet (1832–1883). At the time, calcium carbonate was added to British and European paper. This traditional additive was widely known to be beneficial to handmade papers. Later in the century, when the condition of paper was widely deplored, it was discovered that rather than benefit the paper, an excess of inorganic additives interfered with inter-fibril bonding. This led to strict limitations on the percentage of ash content in British and European paper at the end of the 19th century[1] (Burns 2002). As a result of getting to know this paper from multiple examples, Bertalan believes that a good mat is more beneficial than treatment and no longer elects to use aqueous or other typical treatment procedures to address its brittle condition.

Fig. 7. Master E.S., *Saint Michael Defeating the Devils*, 1467. National Gallery of Art 1997.89.5. After treatment, with removable insert behind loss, without design compensation.

Fig. 8. Master E.S., *Saint Michael Defeating the Devils*, 1467. National Gallery of Art 1997.89.5. After treatment, with removable insert in position over loss, with design compensation.

In the 19th century, the alternative to poor-quality European papers was "China paper" for lithographs and Japanese paper for etchings. These papers were often used as "chines" over secondary supports or as supports in their own right. Outside a controlled environment, Chinese papers were known to develop little brown spots. True, long- fibered, Japanese papers appear to have been in very wide use when available. Often the edges were trimmed, and today they are erroneously described as "wove" paper. Many Japanese papers undergo significant color change within a window mat when exposed to unfiltered daylight.

Toward the end of the 19th century, when academically trained artists began to make etchings, they sought French and Dutch papers made for book printing, which were strong enough to withstand the etching process. When the multiples that artists such as Mary Cassatt (1844–1926), Edgar Degas (1834–1917), and Camille Pissarro (1830–1903) pulled for themselves are examined and documented, the same French and Dutch watermarks appear[2] (Perkinson 1984). In a controlled museum environment, these papers are protected from the wide-ranging condition changes that occur when they have been in private collections. Treatment by conservators and intervention by framers, such as flattening a print by wetting and "stretch mounting" it to a backing, appear to contribute to the extreme changes conservators now observe.

In the first decade of the 20th century, the paper options for an edition tended to be Japanese paper, Arches, or old handmade papers (fig. 9). In the 19th and early part of the 20th century, impressions were often pulled on demand. Finding papers for editions was not just a matter of aesthetic preference but a necessity that often fell to the publisher. In France, Ambroise Vollard (1866–1939) found mills to make new papers and sought the highest-quality papers for his publications. For some early editions, Vollard used Van Gelder Zonen wove paper. Although this paper is well known to paper conservators for its condition problems, its production appears to have been relatively short lived. Untreated Van Gelder Zonen wove paper will invariably have dense areas throughout that appear as more-or-less dark stains in normal light (Bertalan 2015). Having examined and treated numerous impressions on thick Van Gelder Zonen wove paper, Bertalan now advises clients that the stains are due to inherent components in the paper and not a result of mold damage. Once the mold question is resolved, clients are more likely

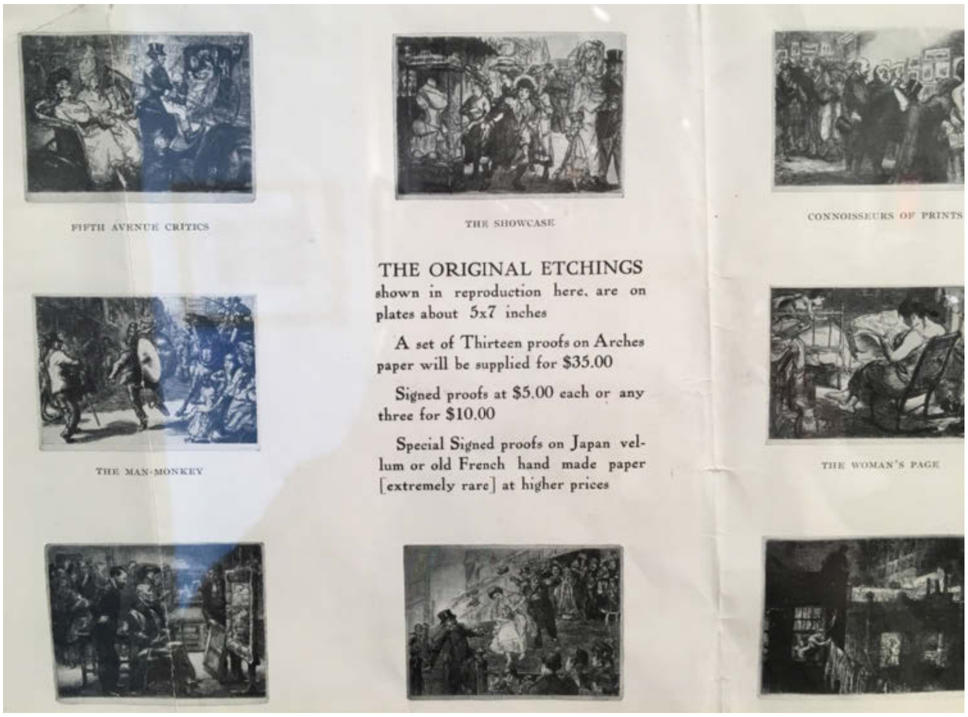


Fig. 9. John Sloan (1871–1951). *New York City Life* portfolio of etchings. 1905–09.

to agree to accept small imperfections in an impression or simply overmat stains in margins.

The most beautiful paper that Vollard found for his editions was Montval. Laid Montval paper was used for Picasso's set of 100 etchings, the *Vollard Suite* (1930–37), and for Picasso's famed *Minotauromachie* (1935) and *La Femme qui pleure* (1937). Montval paper is a mixture of linen and cotton fibers, as compared to most 20th century papers made for printmaking that are composed entirely of cotton fibers. Its condition problems are minimal. It will darken superficially when the surface is in contact with low pH mats or media.

Rives was also used by Vollard for editions of Picasso's prints in the 1930s. Rives, as shown in transmitted light, is an absolutely even and smooth wove paper with very few inclusions. In France, mills tended to specialize rather than compete. Rives produced papers for photographic prints. Early on, it was acknowledged that papers for photographic processes would require a high degree of purity.[3] The papers used for Vollard's editions have been documented; however, many catalogues raisonné of artists' prints do not even discuss paper. It is up to conservators to promote publication of this information.

In the late 19th century and into the 20th, the preeminent paper for printmaking in both Europe and the United States has been Arches wove or cover. Until the 1920s, the Arches papers used for multiples were laid papers. Arches wove paper was used for Henri Matisse's (1869–1954) lithographs of dancers in 1927, but not for the lithographs he did earlier in the 1920s (Bertalan 2013). Arches papers should appear neutral and off-white, not pink or beige. The latter are the result of the extensive changes that occur in an uncontrolled environment. Matisse's *Jazz* impressions (1947), one version on Arches wove from the 1940s, exemplify how far the damage can go. In private collections, when displayed in unfiltered daylight and when poorly framed, not only do the vibrant colors of the pochoir fade, but the paper is extensively altered as well.

Picasso's linocuts are good examples of condition problems very common to Arches papers from the 1950s and 1960s. The extent of damage never goes as far as earlier Arches papers. There are never any unusually dark local stains. There may be a pale brown "burn" from contact with the edges of an acidic mat, or the paper may go buff or yellow where exposed to light.[4] Prints of this vintage tend to be overmatted because the margins are narrow and not very interesting. Any portion of the paper that has been covered by a mat will differ in tone.

The changes in certain Arches papers in the 1960s and 1970s can be so subtle that if there is not another impression for comparison, one might think an intentional plate tone had been used. As observed repeatedly on the ULAE lithograph by Jasper Johns (born 1930) titled *0 through 9* (1960), conclusions about "intended" paper tone can be very wrong. A numbered print from an edition by Johns, purchased at auction, had changed so slightly and evenly that when it was placed side by side with another numbered impression from the edition that had been protected from daylight, the owner began to theorize that the edition had been printed on different papers (fig. 10). Only when it was observed that the verso was the same off-white as the protected paper did Bertalan and the owner realize that the original tone was not beige.

In the late 1960s and early 1970s, paper distributors like Michael Ginsberg of Legion sought new papers for printmaking. A very beautiful paper called *Somerset* was used for etchings and lithographs by Lucien Freud (1922–2011), David Hockney (born 1939), Paula Rego (born 1935), and other contemporary artists. In certain conditions, Somerset Satin White papers turn yellow in contact with buffered mat board—a condition problem that is difficult to accurately document with photography but very easy to remedy.

When conservators treat multiples in private hands, they often examine and treat prints that were previously treated. This affords them an opportunity to judge the success of prior treatment. There is always a perfectly preserved example for comparison. A pristine impression of Mary Cassatt's *Feeding the Ducks* (1894) is printed on off-white paper. The colors are both bold and subtle (fig. 11). By comparison, Bertalan was asked to treat an unevenly stained and blotchy impression that had been previously treated in the 1970s by a reputable colleague (figs. 12, 13).

Fig. 10. Identical papers from an edition compared after approximately 40 years in private hands.

Fig. 11. Mary Cassatt (1844–1926), *Feeding the Ducks*, 1894, drypoint, softground etching, and aquatint, 36.8 × 50.8 cm. Metropolitan Museum of Art, H.O. Havemeyer Collection, bequest of Mrs. H.O. Havemeyer, 29.107.100.

Often, conservators observe that treated stains reappear. Bertalan experienced this with an impression of Matisse's *Grand Bois* (1906). Under ultraviolet illumination, it was apparent that the former treatment had consisted of local brushing of bleach on the verso, possibly with insufficient or no rinsing afterward. Not only had the stains returned, but they were now surrounded by broad white haloes. That condition problems reappear or worsen after conservation treatment should prompt conservators to question whether the causes of stains and discoloration in paper are really understood. In a final example, a print with extensive notations in

Fig. 12. Mary Cassatt, *Feeding the Ducks*, 1894. Private collection. Previously treated in the 1970s.

Fig. 13. Mary Cassatt, *Feeding the Ducks*, 1894. Private collection. Previously treated in the 1970s, detail.

the margins about a slow-drying ink and a paper that tears under pressure, Bertalan sought to show that in addition to the artist, the publisher, and the paper manufacturer, whoever was doing the actual printing would play a role in finding a suitable paper for printing multiples, and all participants contribute to how these works of art come into being.

Sarah Bertalan, Conservator and Consultant for Works on Paper, New York, NY

ANISHA GUPTA

STRIKING A HARMONIOUS TONE: WET TREATMENT OF A MODERN PRINT EDITION

Gupta gave a detailed overview of the treatment of the 24 lithographs that comprise Ben Shahn's *Rilke Portfolio*. The prints were discolored to different degrees, and the goal of treatment was to unify paper tone so the portfolio could be displayed as a group. During the treatment process, Gupta made use of a spectrophotometer to quantify her results. The *Rilke Portfolio* was created in 1968 by Lithuanian-born American artist Ben Shahn (1898–1969). The lithographs illustrate a quotation by Rainer Maria Rilke entitled "For the Sake of a Single Verse from the Notebooks of Maria Laurits Brigge." The portfolio was printed from zinc plates in an edition of 950 by Atelier Mourlot Limited in New York. The first 200 portfolios were printed on Richard de Bas handmade paper. The remaining 750 portfolios, including the portfolio that Gupta treated, were printed on Velin d'Arches paper, also known as Arches Cover in the United States. This paper is mould made, 100% cotton, and internally sized, and has a pronounced grain. It is made specifically for printing.

The lithographs that Gupta treated were included in a de Young Museum exhibition of modern and contemporary works entitled *Printed Stories*. Previously deemed unexhibitable due to the inconsistent yellow discoloration of the sheets, the portfolio was going on display for the first time and exhibition aesthetics called for float matting the prints in their frames.

In general, the lithographs did not have condition issues aside from discoloration, but each print was discolored to a different extent (fig. 14). This was due to the fact that the original owner was a corporate entity that displayed the prints under fluorescent lights in secretary typing pools and in conference rooms with strong natural light. Museum records indicate that the prints were displayed for 23 years, and the amount of light they received ranged from 8 to 30 footcandles. The curatorial mandate for treatment was to make the portfolio appear uniform in a display that would emphasize the sequential and interconnected relationship of the prints in the portfolio. Gupta worked out a treatment plan that incorporated consistent review of the prints with the curator and standardization of results with a spectrophotometer.

Gupta used an X-Rite eXact spectrophotometer[5] (fig. 15), an instrument with both spectrophotometry and densitometry capability; however she used only the spectrophotometry function. Spectrophotometers measure reflected or transmitted light across a light spectrum by assigning a numerical value to the sampling area, representing the reflected light as L*a*b* values. The L* values represent the white to black range, the a* values are the red to green range, and the b* values are the yellow to blue range. Gupta primarily looked at the L* values for brightness and the b* values to see a decrease in yellow. She took spectrophotometer measurements of each paper. To ensure consistency in measurement, she made a Mylar template that lined up with the top left corner of the object and took five readings for each print to have a statistical average value for each one.

Fig. 14. Ben Shahn (American, born Lithuania, 1898–1969), *Rilke Portfolio: For the Sake of a Single Verse*, lithographs, 64.8 cm × 48.3 cm. Fine Arts Museums of San Francisco, Anderson Graphic Arts Collection, gift of the Harry W. and Mary Margaret Anderson Charitable Foundation. 1996.74.434.1-.24. Before treatment, the prints in the portfolio displayed varying degrees of yellow discoloration and most of the prints had severely darkened edges.

Fig. 15. The X-Rite eXact spectrophotometer set up for before treatment documentation of paper tone.

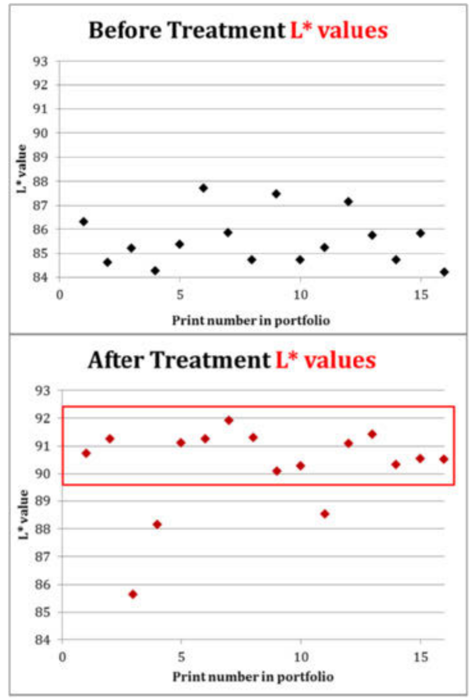


Fig. 16. The L* graphs from before and after treatment. Before treatment, the plotted values show a wide range of black to white values. The values are more closely aligned after treatment.

The portfolio included black and white prints but also a range of colors. Gupta thoroughly tested the inks to ensure that none of them were water soluble, and with Debra Evans, she bathed the prints in an initial filtered tap water wash of pH 6.75. Tenacious discoloration was reduced by then bathing the prints in a warm bath of ammoniated water. The ammonium hydroxide adjusted the pH of the water to a higher alkalinity and helped to release the discoloration more effectively. The higher temperature of the water also aided in drawing out discoloration. After evaluating the results of bathing with the curator, the conservators proceeded to light bleaching. The prints were light-bleached incrementally. They were placed in a tray covered with UV-filtering Mylar. A small fan was run near the trays so that there was no excessive heat buildup. The lamps were about 24 in. above the prints. They were placed in a bath with 45 to 50 mL of magnesium bicarbonate and 4 L of deionized water, with two drops of 3% hydrogen peroxide. Since the papers were of a good quality, 100% rag, they could withstand the light bleaching treatment. The prints were light-bleached in intervals of 3 hours, followed by a 10- to 15-minute rinse bath and then air-dried overnight. Although one print was bleached 12 hours, most prints averaged about 6 hours. There was minimal risk in light bleaching the *Rilke Portfolio*, particularly in terms of the colored inks, because the prints had already been exposed to so much light already.

Each morning, Gupta and the curator met to visually assess the efficacy of light bleaching and to determine how many more hours of light bleaching each print needed. This was challenging because the curatorial and conservation team did not want to overbleach any print, as the goal was to keep the portfolio as uniform as possible. Gupta had originally envisioned using the spectrophotometer at this stage, but it was not feasible since it takes a considerable amount of time to take the measurements every morning and then determine which prints to light-bleach.

Once the conservation/curatorial team was satisfied with the level of brightness, Gupta flattened the prints by misting with filtered tap water and sandwiching between spun-bound polyester and board. The prints were pressed in a large air mattress press for 13 days. This large-scale press is similar to one at Crown Point Press: the boards are placed into the press and an air mattress is inflated to compress the pile and provide pressure. Initially, cool air was pumped through the boards for two hours to speed up the drying and keep the prints flat.

In terms of the results from the spectrophotometer, two graphs (fig. 16) indicate that although the L* values (black to white spectrum) were more spread out before treatment, the values came together after treatment, an indication that visual analysis was an effective method of evaluating uniformity of paper tone. With the exception of a few outliers, the numbers cluster between 90 and 92, very close to 100, which is equivalent to white.

Examination of the b* values reveals results similar to L* (fig. 17). As the values decrease, the prints become less yellow. The graph indicates that not only are the prints moving away from yellow, they are also clustering together.

To Gupta, the spectrophotometer measurements indicated that using visual assessment can be just as good and a lot less time consuming than applying scientific measurements to each treatment. The outcome of treatment was similarly satisfying, as the prints looked uniform during display, and without the distracting selective discoloration to individual sheets, the bold and graphic quality of Shahn's work was much more evident (fig. 18).

Anisha Gupta, Andrew W. Mellon Fellow, Fine Arts Museums of San Francisco

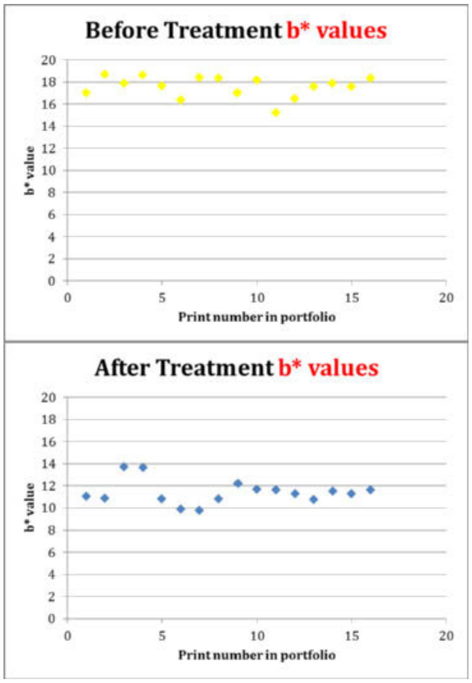


Fig. 17. The b* graphs from before and after treatment. Note the lower b* values after treatment, an indication that the paper is less yellow. Also note the values cluster together after treatment.

DISCUSSION SUMMARY

These three presentations generated a lively dialogue touching on the merits and limits of referencing other prints as touchstones for treatment goals. Several participants shared their experiences with navigating curatorial expectations, which often diverged from the conservators' own knowledge of paper history and the historic use of bleaching treatments. It was noted that cultural attitudes about discoloration and staining can change and influence the course of treatment, particularly when attempting to unify an edition or present individual prints in a sympathetic manner to their cohorts in an exhibition.

Fig. 18. The results of treatment were a consistent paper tone across the portfolio, and the works were displayed together on a single wall in *Printed Stories* at the de Young Museum, San Francisco.

The speakers were asked how they worked with curators to describe paper color, and if there were any words or discussion that led them to conclude what "the right color" for a paper should be after treatment. Bertalan mentioned that she has had clients who wanted the print to "pop"—a pretty disconcerting concept to a paper conservator! Gupta described how the curator for the Ben Shahn portfolio was concerned that the prints looked *dingy* and had wanted them to look *more alive* as they assessed the prints after each bleaching cycle. Gupta interpreted these terms to mean "brighter" or "whiter," but she herself was concerned that they not get "too white." The end point for treatment was a compromise between curator and conservator preference, when a uniform level of brightness for all prints in the edition had been reached to the satisfaction of both.

Walsh remarked on the difficulty of describing paper color to curators, which she generally avoided in her discussions of treatment. In her experience, most 15th century prints in the NGA are quite white, which she attributes to high standards of papermaking during that period. She also wondered if many older prints have already been treated to remove discoloration, often with stronger bleaching agents than those used today. A paper conservator in the audience suggested that we look for cohorts of these papers in bound volumes, as they have had little or no treatment nor any light exposure. She agreed that the 15th century papers she observed in bound volumes are remarkably white, and recent analysis of them has indicated high quantities of calcium. She went on to remind everyone to share their experiences in treating some of the more commonly used printing papers, such as Arches, Rives BFK, and Van Gelder Zonen, particularly those who have been in the field a long time, and those who have witnessed the many changes in bleaching agents over the years.

Walsh emphasized that in her experience working with all kinds of curators at different kinds of institutions, one of the most powerful skills conservators can bring is their own experience of treatment. Consultation with curators can help refine goals, but without a lot of practical experience with a particular paper over a period of time, one is really in the dark when trying to describe the expected result to a curator. She continued by saying that colleagues in private practice and in regional centers regularly do much more work than those working in museums, so it is important to have a forum for experiences like theirs, and for everyone to talk more about treatment to help predict outcomes. She added that reliance on cohorts and multiples to inform treatment decisions may be useful for modern and contemporary works but is perhaps misleading when thinking about older prints. Older prints likely have received some kind of intervention during their long history, perhaps with stronger bleaches than would be used today. Do we try to match the cohorts, or do we treat according to our current aesthetic? What if a print will look different on the wall than others adjacent to it?

To the first question, one participant expressed her desire to see more exploration of "the connoisseurship of stains," a concept championed by John Krill. Walsh commented that the reticence of her curator to approve any changes to the aged appearance of old master prints seemed to prioritize historic condition over how we might expect to see them now in a museum context. Another noted the opposite experience at her museum, in which curators have been in favor of removing stains from prints if they enter the collection in much better condition than had been documented. To the second question, a conservator relayed her experience with some Picasso lithographs that she had initially considered to be too oddly discolored for exhibition. Upon seeing the exhibition, however, she saw the prints displayed alongside others with a similar kind of discoloration and thought they looked acceptable in that context. Walsh observed that curators will research an artist's work for years prior to an exhibition, but conservators often do not get to see a full range of an artist's work until the day of the exhibition, after the treatments are done.

The audience was asked how they worked with curators when asked to approve the exhibition of a few prints from a series, and what recommendations they have made regarding their exposure. In her experience, conservators have recommended that either the whole portfolio be displayed at once or that the prints be rotated through the course of the exhibition so they are not exposed differentially. She also asked how conservators have kept track of light exposure. One conservator recalled how her museum wanted to display only half of a portfolio of eight silkscreens by Andy Warhol because there was only enough space for four. Ultimately, conservators agreed, but only if the other four prints were rotated in halfway through the exhibition. The use of a spectrophotometer was considered as an option for evaluating the impact of any potential differences in exposure, but the turnaround time was too quick.

The discussion then addressed the question of spectrophotometers to objectively measure changes in paper color after treatment or exhibition. Early on, one participant mentioned the possibility of using a densitometer, rather than a spectrophotometer, to measure density loss in the ink and paper following treatment, as used by photograph conservators. Gupta commented that spectrophotometer readings would be used in tandem with tracking lux hours of exposure for the Shahn portfolio. In another conservator's experience, it was noted that spectrophotometer readings correlated well with visual assessments by conservators in controlled lighting conditions and agreed with Gupta that it was an effective tool to bolster the validity of, or confidence in, our own eyes.

Participants also discussed the difficultly of predicting a paper's original color, complicated by the uncertainty surrounding causes of paper discoloration and staining. A conservator shared her own experience with treating edition prints that had not responded as predictably as the Shahn portfolio, and remarked that even though papers may seem identical, they may have different histories that cause them to respond differently from one another.

Bertalan was asked what might explain the discoloration she observed in Somerset paper when stored in contact with buffered mat board. She responded that pigment additives, such as titanium dioxide, might have had an impact. Walsh wondered if bluing agents may have been extinguished in the paper, causing it to shift toward yellow. One conservator expanded on the possible causes by citing research at the Getty, which measured localized staining in books caused by alkaline paper slips.

Later in the discussion, a conservator pointed out that Somerset paper was offered in multiple buff colors by the 20th century, so when one thinks he or she is working with "Somerset" paper, it does not necessarily mean that they are all the same. In addition, she has observed alterations in paper color even in closed sample books, so over time, a "white" paper can look similar to the paper labeled "buff." This becomes especially complicated when thinking about bleaching treatments, when "white" is not the color the paper wants to be.

Bertalan was also asked what might have caused the white blotches within dark-stained areas in the Cassatt print that she had illustrated in her presentation. Although the mechanism may be unknown, she emphasized that we should consider how aqueous treatment might have affected these modern papers. One paper conservator remarked that she and her colleagues in private practice have observed many 20th century prints on Arches, Rives BFK, and other papers with similar types of staining and wondered if aqueous treatment should be reconsidered for such works.

Participants then discussed the propensity for Van Gelder Zonen papers to exhibit these stains, first referred to as reverse foxing some 35 years ago, perhaps by Keiko Keyes. Several conservators cited their own or others' investigations into the problem, particularly in Picasso's *Saltimbanque* series. In all instances, including a recent, comprehensive study soon to be presented and published in Europe, there were no detectible differences between the white areas and the overall paper. One conservator wondered if newer technologies, such as scanning XRF, would give a better picture of what is going on. Bertalan thought microscopy and sampling might be necessary for some of these questions. Another added that her use of micro-fade testing to assess prints on Van Gelder papers indicated that they were quite light stable.

Bertalan emphasized that the printing process itself was very rigorous, and depending on studio practice, papers could be wet for days or be subjected to multiple wetting and drying cycles during extended runs through the press. Another conservator added that in her experience as a printmaker, she also wondered if a deterioration mechanism is set up when printing papers are wet out and stacked during the printing process. She knows that 20 or 30 years ago, some printers used formaldehyde and other kind of biocides in their water baths to prevent mold when they were doing long print runs.

CONCLUSION

As the session drew to a close, there was general consensus on the importance of sharing treatment protocols with one another, particularly by conservators who have been practicing for a long time, and who are in a position to evaluate how treatments have aged over the years. Many in the audience asked for an online repository of images, such as a Wiki, which several specialty groups already use to share images.

NOTES

1. Conservators in private practice are generally expected to rescue, transform, or "work their magic" with treatment. Bertalan's private practice has instead focused on consultation, dialogue, and providing the kind of conservation support found in a museum context to a small number of clients over many years. She has often recommended cautious handling and preventive conservation measures rather than treatment interventions.
2. Dambricourt Freres, Blacons, Van Gelder, and Arches watermarks were found. Whatman, Van der Ley, D&C Blauw, and Adrian Rogge papers were also used.
3. Under UV, untreated examples of Montval laid and Van Gelder Zonen wove paper will absorb. Untreated Rives tends to reflect yellow.
4. On these prints, the Arches watermark, in large Roman letters, is invariably in reverse. Picasso's linocuts were all printed by the same professional printer on the reverse of the Arches sheet.
5. Data recorded in CIELAB 1976 color coordinates, using illuminant D65 and 10 degree observer.

REFERENCES

Bertalan, S. 2013. A note on Matisse papers. In *Matisse: The essence of line*. New York, NY: Marlborough Gallery.

Bertalan, S. 2015. Foxing and reverse foxing: Condition problems in modern papers and the role of inorganic additives. *AIC Book and Paper Group Annual* 34: 13–22.

Burns, T. 2002. "A serious and universal evil": The early scientific study of paper deterioration. In *Works of art on paper: Books, documents and photographs: Techniques and conservation; contributions to the Baltimore Congress, 2-6 September 2002*., eds. V. Daniels, A. Donnithorne, and P. Smith. London, UK: International Institute for Conservation of Historic and Artistic Works. 36–41.

Fletcher, S. 1970. A re-evaluation of two Mantegna prints. *Print Quarterly* 14 (1): 67–77.

Lehrs, M. 1970. *History and critical catalog of German, Netherlandish, and French copper engravings in the 15th century*, vol. 2, no. 154. New York, NY: Collector's Editions.

Perkinson, R. L. 1984. Degas' printing papers. In *Degas: The painter as printmaker*. Boston, MA: Museum of Fine Arts. 255–261.

Rubin P. L., and A. Wright. 1999. *Renaissance Florence: The art of the 1470s*, no. 65. London, UK: Yale University Press for National Gallery Publications.

RACHEL FREEMAN
Associate Paper Conservator
The Art Institute of Chicago
Chicago, IL
rfreeman@artic.edu

CYNTIA KARNES
Independent Paper Conservator
Toronto, Canada
cyntia.karnes@gmail.com

HARRIET K. STRATIS
Former Senior Research Conservator, Art Institute of Chicago
Stratis Fine Art Conservation LLC
Chicago, IL
harriet@stratisartconservation.com
hkstratis@gmail.com

ANGELA ANDRES, SONYA BARRON, AND ANAHIT CAMPBELL
DISCUSSION GROUP CO-CHAIRS

Library Collections Conservation Discussion Group 2017 Unexpectedly Expert: Diversifying Your Skills to Cover All the Bases

INTRODUCTION

The program theme for this year's session was "Unexpectedly Expert: Diversifying Your Skills to Cover All the Bases." This topic was selected because it is a common experience that many library and archives conservators share. We are often the one and only conservator employed by our institution. Or perhaps we work with other book and paper conservators but our institution has extensive holdings that are not book and paper based. Having to learn and master new skills on the job encourages us to stretch and grow to rise to the challenge.

A panel of emerging, mid-career, and highly experienced conservators was assembled to share their experiences facing a variety of professional challenges that fell outside of their immediate areas of expertise. As a result, a diverse range of subtopics emerged: examples of single-item treatments, collection care projects, construction of new conservation labs, and innovative ideas for lab workflows and collaborative strategies, as well as theoretical and ethical considerations inherent in our decision-making process. The engaging audience-driven discussion session that followed the presentations took many different and unexpected directions.

PRESENTATION SUMMARIES

SONYA BARRON
THREE-DIMENSIONAL OBJECTS IN THE ARCHIVES

At Iowa State University Library, dealing with a large number of high-priority three-dimensional objects in archival collections is a pressing issue. Some common hurdles that many conservators must overcome are lack of adequate training, lack of funding to hire a qualified professional, and lack of time to deal with the whole issue. It is desirable to maximize the effectiveness of preventive conservation measures and to avoid performing invasive item-level treatments on the artifacts.

The presenter conducted several consultations with Marilyn Pool, an objects conservator at Arizona State Museum. These conversations shed light on the bigger picture of collections care in an ethnographic objects museum and archaeological repository. The museum's approach to preservation is collection-level oriented, much like in libraries and archives. Some of the preservation strategies for their large grant-based projects include doing condition assessment surveys, opting for supportive housing in lieu of conservation treatment, performing targeted structural repairs for high-priority objects, and assessing preservation actions after a period of five years. Some go-to online resources Pool recommended were the Society for Preservation of Natural History Collections, National Park Service Conserve-O-Grams, the Canadian Conservation Institute, and Connecting to Collections Care Online.

Two examples of perishable artifacts were presented to illustrate an effective minimalist approach to preservation of objects in an archives setting. Both items bear cultural significance to Iowans and are popular with the Iowa State University campus community. The first was an ear of prize-winning corn from 1907 called the *Grand Champion*. It was mounted precariously in a heavy historic display case with rattling glass. The second was a small slice of the Biggest Rice Krispie Treat™ Ever Made, dating from 2001. Because both of these food items are potentially highly attractive to pests, they were taken through a standard freeze-and-thaw cycle, described in detail in the NPS Conserve-O-Gram 3/6, 1994. The process eradicates insects, their larvae, and eggs, as well as deactivates mold spores. After being removed from its original display case, the ear of corn and the display case were rehoused side by side in separate compartments of the same box. The new storage enclosure served as an

This open discussion took place on June 1, 2017, during AIC's 45th Annual Meeting, May 28-June 2, 2017, Chicago, Illinois. The moderators organized and led the discussion and recorded notes. Readers are reminded that the moderators do not necessarily endorse all 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.

attractive temporary display solution. Both the corn and the Rice Krispie Treat were sealed in heavy-weight polyethylene on all sides, using a Polyweld unit and a Colibri machine, respectively. Other materials and techniques for rehousing included using Volara foam and lining an Ethafoam cut-out with Teflon film.

Sonya Barron, Iowa State University

DEBORAH HOWE
REACHING OUT: HELP WHEN YOU NEED IT

Conservation labs located in remote rural areas face particular challenges in finding resources. The presenter, collections conservator at Dartmouth College Library, reflected on the resources and options available to conservators in such a position. There are tangible resources beyond a campus setting, such as the AIC Directory and other networks of experts, that a conservator may make use of. Often overlooked are the on-campus facilities and services outside the conservation community. The Dartmouth campus is home to experts in a variety of fields, such as science, art, theater, and engineering, whose knowledge can potentially aid and inform the work of conservators.

Two projects in particular, the treatments of a collection of papyri and an oversized antiphonal binding, were discussed as examples of the preceding strategies. For the papyri project, the presenter sought the help of Papyrus Conservation Expert Leyla Lau-Lamb and her information network, *University of Michigan Information System: Guidelines for Conservation of Papyrus*. When planning the conservation treatment of an extremely large antiphonal binding, the presenter took advantage of a lab visit by Giselle Simón, conservator at the University of Iowa, who has extensive experience in working with antiphonal material. Although visiting experts might only be available in person for a short period of time, their visits provide the opportunity to form a long-term plan and strategy for the object or project at hand. Activities that could be performed ahead of time, such as photographic documentation, were done by local staff to free up the expert's time to do the work that only he or she could provide. In addition, while collaborating with other departments on campus may come at an added financial cost, it is a convenient and effective way to access highly specialized knowledge, studio space, or additional resources and materials needed to complete a project. For example, the Woodworking Workshop and Jewelry Studio at Dartmouth were used for the treatment of the antiphonal boards and in the fabrication of metal hardware for the binding. Available funding, visiting experts, and on-site resources are best utilized through careful organization and an openness to collaboration, allowing conservators to help fill in the gaps in their knowledge.

Deborah Howe, Dartmouth College Library

ELIZABETH STONE AND JANET LEE
SIX DOLLS, FOUR SHOES AND A TIGER

Conservators are often confronted with challenging treatments outside their comfort zone. Many conservators do not have local experts to consult and may have to rely on assistance outside their geographic region. There are strategies and creative ways to overcome the problems that distance may pose, as was the case with the preservation of a small collection of textile objects at the University of Iowa Libraries. The textile objects—Chinese mission dolls, children's shoes, and a tiger pillow—were collected by a missionary in China. When it came time to strategize about treatment and rehousing for the unusual objects, the Presenter reached out to Janet Lee, conservation assistant at the New York Historical Society with an expertise in textiles, to gain more information about the nature and historical background of the objects themselves, as well as to consult on how to best preserve them. Texting, video chat, digital file exchanges, and other modes of communication were employed to facilitate long-distance collaboration. The conservators combined online research with direct examination of similar collection objects accessible to Lee at the New York Historical Society to gather necessary background information on the history and cultural significance of the objects.

Condition issues included pest damage and soiling. The presenter consulted with Lee to determine the best approach to the treatment. When unexpected issues arose during the treatment process, such as the discovery of sawdust coming out of one of the dolls, Lee helped the presenter determine that the sawdust was the doll's stuffing and not additional pest damage. To avoid any ambiguity that might result from long-distance communication, Lee created clear and simple instructive diagrams to share. The diagrams offered detailed representations of Lee's housing design and basic textile treatment techniques such as the "sew-mend" and provided enough direction for the presenter to execute them independently. Working knowledge of both textiles and library collections was blended together to design a custom storage enclosure with movable compartments appropriate for storage of the objects in a library setting. Further work on the remainder of the objects will be completed in a similar manner between these two collaborators.

Elizabeth Stone, University of Iowa Libraries
Janet Lee, New York Historical Society

ASHLEIGH SCHIESZER
DEVELOPING LEADERSHIP SKILLS IN CONSERVATION

Acquiring managerial and administrative skills in a new professional role is a challenge that many emerging conservators face. The presenter, conservator and co-manager at

The Preservation Lab, a hybrid collaborative lab, admitted to having little training or experience in the management of staff or in large-scale collections preservation at the time she began in the position. The Preservation Lab provides conservation services to more than 50 libraries within the lab's network and includes professional staff, technicians, student employees, and volunteers. To be successful in her new role, the presenter sought out training and resources to develop her professional management skills. She graduated from an 18-month leadership course through the Public Library, attended local university workshops and retreats, and utilized training opportunities offered by AIC. These educational resources provided different perspectives on leadership to help shape a personal leadership style and inform responses to various management situations. Interpersonal skills and emotional intelligence can also be cultivated through one's own personal reading and research. Emerging professionals were encouraged to cast a wide net when seeking to develop their own management expertise, making use of local and regional resources, professional organizations, and mentors.

The unique nature of The Preservation Lab gives rise to a special set of management challenges that the co-managers have developed strategies for addressing. The facility is shared by two institutions with distinct missions and cultures; staff employed by either institution work equally on materials from both. The co-managers—a conservator and a preservation librarian—focus on transparent communication and clearly defined priorities, and make use of the lab's open layout to encourage collaboration among staff. They balance the potentially competing workflows for general and special collections by employing standardized treatments for general collection materials and holding regular meetings with selectors to discuss special collections treatments. They also look for ways to maximize both productivity and staff job satisfaction. Collaborative team learning activities, for instance, achieve both of those goals and also help to create a unified lab culture.

Ashleigh Ferguson Schieszer, Public Library of Cincinnati & Hamilton County and the University of Cincinnati

SUZANNE MORGAN
"I LEARNED IT BY WATCHING YOU!"

A search for resources to inform a textile rehousing project prompted the presenter, a book conservator unfamiliar with textile preservation, to consult the literature for help. Although many written and photographic resources on the subject were available, none depicted the process in the desired level of detail. Research on the Internet eventually led to a step-by-step textile housing video produced by the Minnesota Historical Society. That video enabled the presenter to finally visualize, take on, and successfully complete the project.

Building on that experience, the presenter used videos as a teaching tool to conduct a week-long workshop on library preservation through the Myanmar Librarian Training Consortium. Enrollment in the workshop was high, so workshop organizers planned to divide the participants into three groups. One group would receive hands-on instruction while the others watched training videos in a separate room. Following the successful experience with the textile video, the presenter expected to find existing library preservation training videos available on the Internet and to supplement them with some original video content. However, this proved difficult; searches for the keyword "conservation" yielded many hits on the subject of *ecological* conservation. In addition, some topics within library preservation and conservation, such as care and handling of materials or videos of conservators at work, were very well covered, whereas other areas were underrepresented or missing altogether. After eventually locating enough online material for the bulk of the training, the presenter used equipment available in the Arizona State University (ASU) makerspace to edit excerpts from existing videos together with original content to create the workshop training videos. Although the process was labor intensive and time consuming, the resulting videos were well received at the workshop. The "magic of video" as a training tool was praised, and those in the audience were strongly urged to produce their own preservation and conservation training videos for the benefit of other conservators and the general public alike.

Suzanne Morgan, Arizona State University Library

JUSTIN JOHNSON
HOW DO I BUILD THIS? UNDERSTANDING AND COMMUNICATING THE LANGUAGE OF DESIGN AND CONSTRUCTION

At the University of Washington Libraries, conservators gained valuable experience working with architects, contractors, and consultants on the planning and design of a new conservation lab. Early on in the process, it was clear that the different parties involved did not share the same vocabulary or perspective on the project. Conservators found it challenging to effectively communicate to the architects exactly the kind of space that they needed, and because some terms can have multiple interpretations, it was essential to establish very clear and open communication. Design versus functionality, for instance, or a seemingly simple matter of whether to refer to the space as a "lab," a "center," or a "studio" were areas where confusion or miscommunication could occur, possibly resulting in unintended features in the new space. The conservators came to realize that what seemed like minor design changes to them—adjustments of just a few inches—were perceived very differently by architects who saw the ripple effect that those changes would have on the design and construction process.

The conservators also learned that communicating their priorities was equally as important as communicating their vision and purpose. Conservators expected that a portion of the new space that was designated as a conference room would also be used for assembling enclosures. This dual purpose was not fully understood by all on the design team, which inevitably led to complications in how lighting engineers would treat the space. Fortunately, an expensive mistake was avoided when conservators noticed this discrepancy. They carefully reviewed the lab plans to ensure that the intended use of each area was clearly conveyed by its label on the plan. However, the conservators admitted to some difficulty in maintaining this level of focus on details large and small over the years-long course of the project. Inevitably some things were lost in translation as successive iterations of the plans passed between conservators and architects and back again. The conservators found it useful to keep track not only of what they wanted in the new space but also of what they had *communicated* that they wanted to avoid situations where architects could "fill in the blank" in the absence of clear instruction from conservators. As both sides learned to ask more questions of the other and became better versed in the language of each other's disciplines, the plans took clearer shape and became a more accurate representation of the conservators' vision.

Justin Johnson, University of Washington Libraries

SUSAN RUSSICK
WHAT COULD POSSIBLY GO WRONG? RISK MANAGEMENT WHEN PROPOSING TREATMENTS

When library and archives conservators are faced with collection materials to treat, the objects may not always fall neatly into the conservator's area of specialization or any well-defined category, and hiring a specialist to perform treatments on materials that are often peripheral to the collection is rarely an option. The AIC core document *Essential Competencies of a Conservator* can be helpful in determining which resources to turn to so that an informed decision about treatments can be made.

Meeting with and listening to curators as a first step can shed light on the priority and significance of an object by placing it within the context of the institution's collection. A conservator may take a cautious approach to working with unfamiliar materials while determining what degree of intervention is needed based on existing expertise and available resources. Some helpful strategies to be considered in decision making and in the process of treatment are understanding the physical materials in their most basic form, revisiting what is known rather than what is unknown, employing basic conservation techniques, and focusing on the "big picture."

The presenter shared several case studies illustrating how these strategies were applied to objects in the Northwestern University Libraries conservation lab. The conservation literature and web-based resources such as the AIC Wiki, ConsDistList, STASH, and webinars can offer consistent and reliable information when approaching conservation in unfamiliar territory. When multiple resources show a consensus on the treatment of a type of material, that confirms that the objects and therefore the treatments are more predictable. The conservator can move forward with greater confidence. Where the literature includes more qualifications or disagrees, a specialist is more likely to be required.

Online research into preservation of glass plate negatives served as an effective tool in helping the conservators cross over from rehousing into minor treatment. Sometimes applying book and paper conservation skills to an object with similar characteristics can make the challenge of treatment less daunting. In evaluating the challenge posed by a Nobel Laureate's oversized chalkboard with writing that needed consolidation, it became clear that it was not the specific task or material that was not well understood but rather the large size of the board that complicated the treatment. The chalk writing was consolidated with funori using an ultrasonic mister. Specialists can be consulted or contracted to help with challenges that are beyond the expertise of a book and paper conservator. Cynthia Kuniej Berry, local paintings conservator, engaged the Northwestern University Library conservation staff in a workshop on the care of paintings, which helped them improve housing and storage for a group of paintings in their collection. When a high-priority taxidermy object needed treatment, Lisa Goldberg, an objects conservator in private practice, performed the bulk of the complex work while library conservation staff provided support. This enabled them to observe the expert at work and to expand their expertise by learning from her. Sometimes a conservator may decide that attempting treatment on a vulnerable object is too risky, regardless of expertise, and simply housing the object is the best approach. Book and paper conservators will continue to work on objects that stretch their expertise; taking on these challenges is a way to increase knowledge and improve skills for future treatments.

Susan Russick, Northwestern University Library

DISCUSSION

After the last presentation, the moderator opened up the floor for questions, comments, and answers. Due to the speakers' coverage of a diverse range of topics, the discussion took several different directions. The contents of the discussion are summarized and paraphrased in the following.

CONSTRUCTION OF NEW CONSERVATION FACILITIES

Commenter: In your experience, from an architect's perspective, what is the functional difference between calling your conservation facility a "lab," a "center," or a "studio"?

Justin Johnson: I think it best to be as ambiguous as possible in the beginning. The architectural firm immediately hired a lab consultant, which may have been more than we needed. While we were using laboratory equipment, what we were building was not a conventional scientific *lab* with the associated chemistry apparatus. We ultimately went with the word *center* because it was felt that it was the most appropriate for potential fundraising and naming opportunities. Right now, our sign reads as "Blank" Conservation Center. The word *studios* seems to convey a different meaning, and the word *lab* may be inaccurate by giving the impression of a facility that is more sophisticated than what we have.

Commenter: At the Holocaust Museum, we recently opened a large, brand new Collections and Conservation Center. I was fortunate that the museum already has an architect on staff for specific projects, so he and I have been working together for over 20 years. He has been to the conservation labs and knows of our work, but I realized that there was still a lot of educating to do. I adopted a useful that came from a conservation scientist at the National Gallery. When they redid their labs, she organized a "functional visit" for the architects. Our visit was not as detailed as I would have liked, and it happened in short spurts over a few weeks. We invited the architects and designers to come in and see us work. Sometimes it was staged, and other times it was actual work. They could see and understand how we moved around a table or a piece of equipment, how the function of that piece of equipment related to other activities in the lab. This enabled them to see what we do in a holistic sense.

JJ: We went through the same process when we had the architects come in. Unfortunately, the space that we had going into the project was so bad that it was hard for them to envision the potential of what it could be. It would have been nice to send the architects to other labs to actually see the spaces where conservators work.

Commenter: Yes, we did that as well. The visits to other labs were a great help in moving the project forward.

Commenter: Even sending your architect to see other labs, or working with an architect who has already designed other labs, is not proof against getting some very strange results. You still need to check all the little details of their output.

Commenter: At the Indiana State Library, we chose to use the word *lab* because we felt it gave us more legitimacy in the eyes of the state. We wanted to be seen as important and irreplaceable to the institution, in view of potential state funding cuts in the future.

JJ: In the beginning of the project, we talked about the same thing and it probably led to too much legitimacy, in a sense. The university's Environmental Health and Safety Office became involved to make sure that all regulations were followed. Representatives came to do a safety inspection and said, "You are not a lab, don't call it a lab."

Commenter: Penn State is in the process of building a new lab. The word *center* has been suggested so that Environmental Health and Safety would not have to be involved. In regard to the functional tour idea, it would be very costly to have an architect travel from central Pennsylvania to Washington, DC. I have been to many labs over the years, but my notes were not detailed enough to be able to pass on to the architect. Considering the videos that have been mentioned in this panel, would some of you be willing to put together videos of your lab spaces? They could go up on YouTube, where they can be accessed by the architects and the design team. We are looking to have all of our work stations be adjustable height and hopefully ADA accessible.

Suzy Morgan: I really love that idea. I would suggest putting those videos on the Wiki.

JJ: There was a great live video tour done by the Smithsonian a couple of weeks ago. It was informal but very illuminating in terms of how their space was laid out and why.

Sofia Barron: It would be important to identify specifically which conservation labs you would want to see on a list of these video tours.

Ashleigh Schieszer: Justin, could you talk about the three-dimensional representational tool that you used to build a virtual model of your lab, which you had discussed in your talk during the Sustainability session?

JJ: Live Home 3D Pro is a commercially available app that people use to design their bathrooms and kitchens. We were able to plot all of our design specifications into the program, which allowed us to do a live vetting of our space. We were able to move furniture around in real time, to stand at our own height, and to reach for things in the space. The software is connected to a virtual warehouse of three-dimensional models of furniture, lighting fixtures, and specialized equipment, including humidification domes and board shears. It's a powerful tool for people who want to experiment without spending a lot of money.

Commenter: Coming from the State Library of New South Wales in Sydney, Australia, I would like to express my support for the Wiki idea. It would be very beneficial to have access to international online resources on new lab construction, since sending architects to the UK or the U.S. would be out of the question for us.

Commenter: When working to construct the first-ever conservation lab in Trinidad and Tobago, I tried to help administrators understand what preservation and conservation actually are. Throughout my years of graduate study, I took pictures of every single lab that I visited. I created a Facebook album with captioned photos and walked the designer through the images. I pointed out features that I liked and asked whether those would be possible to include in the newly constructed work environment. With new emerging technologies, [the] sky seems to be the limit. I am even more excited about being able to share videos, live video tours, and 360 virtual tours of lab spaces.

Commenter: At Rutgers University, having Environmental Health and Safety involved in testing our fume hood was helpful because the facilities staff came and fixed it free of charge, bringing it up to spec. Yes, there is the added burden of maintaining MSDS sheets, proper labeling and tight records of chemicals, regular scheduled respirator testing, and such, but that may be an acceptable trade-off when weighed against the benefits.

MANAGEMENT: COMMUNICATION, WORKFLOWS, AND STAFF

MANAGEMENT: COMMUNICATION, WORKFLOWS, AND STAFF

Commenter: Question for Ashleigh. How does your lab remain accountable as you split your work between two institutions?

AS: We use an Access database where we record treatment time spent, among other things. The time spent is weighted based on who is performing the treatment. The cost to the institution is determined by whether the work is done by a technician, a conservator, an intern, or a volunteer. We also track the percentage of special versus general collections work that is done for each institution.

Commenter: In most labs, the time spent on general collection book repair has been decreasing. There is a shift toward doing more special collections treatment. How do you work with technicians to help them acquire these skills?

AS: We utilize the specialized skills that our technicians already have, such as knowledge of photography for developing expertise in conservation photographic documentation. I have taught workshops to the technicians on topics like matting and hinging and encapsulated bindings. Teaching helps me reach a deeper understanding of procedures. As technicians acquire and master new skills, they can in turn teach interns and volunteers, which saves me time and provides them with the opportunity to gain the skill of training others.

SM: I have delegated many tasks to student workers. The distinction that only I can work on special collections materials made my workload impractical. Projects can be broken down into chunks, where some parts are appropriate for the conservator to do, such as treatment, and other aspects can be dealt with by a student or a technician, such as rehousing or documentation.

Commenter: How do you facilitate effective communication within your institution?

SM: As the only conservator at ASU, I find so-called house calls to be an effective communication strategy. I walk around the building and talk to staff, which is how I have discovered many "problem areas." Doing this gives Conservation a physical presence in the building.

SB: When working on collaborative projects, my solution has been to hold group meetings, where all the stakeholders are present in the same room and are able to comment in real time. In order to remain accountable, it helps to have an electronically accessible editable meeting agenda, meeting notes, and action items, as well as scheduling a next meeting in advance. When taking in items for treatment, I meet with all of the archivists together every four to six months. They transfer a group of objects to the lab, and we talk together about the available options. They bring no more items for me to treat until these treatments are completed, not unless there is an emergency situation or a donor event. In the interim between meetings, the curators compile a prioritized list of objects that they want to have treated. This is a workflow for collections maintenance treatments, not for digitization or exhibits.

AS: We have similar workflows. It makes it easier for librarians to know that they can count on that meeting to bring over their objects. I have a corresponding intake meeting for the technicians. I come up with a treatment plan and divide up the work into segments. I fill out a photo documentation sheet for an assigned technician to perform photography. A set of paperwork travels with the object so that work steps can be recorded by different technicians as the project progresses. We put all of our tasks on the whiteboard so everyone can see which actions are assigned to whom.

Commenter: I have started to do Faculty Hours in Special Collections. The preservation librarian and myself spend an hour answering questions and looking at items. Questions come to us from library assistants, curators, catalogers, and members of the community. We divide up the inquiries based on our expertise or filter them through to our digital preservation librarian.

FACING LIMITATIONS OF COLLECTIONS STORAGE

Commenter: At the University of Virginia Libraries, we often encounter items that we are not used to dealing with in the conservation lab. One of the struggles that we have is to find additional storage space, when items that had been folded up become unfolded and grow in size, so to speak. Could the panel speak about this issue and how you deal with it in your own institutions?

SM: The large wedding dress that you saw in my presentation is now stored on top of a cabinet nowhere near the collection that it is associated with. There is definitely a shortage of space, so we store the oversized items where we can find room. I, too, am designing a lab in the renovated library space, and I am pleading for wider doors and more space in general. There is still the mentality that we are just a library, but I believe that with all the artifacts that we have, we are no longer a library but a small museum.

Susan Russick: We measure all of the shelves, and we have a maximum enclosure size that we adhere to. If at all possible, we will fit the item on the shelf. If we can't do that, we have to accept that the oversized item will be precariously balanced on something or sitting on pallets on the floor. We have a number of dresses, which we decided to pad out and fold to fit into a box smaller than the ideal size in order to store them on shelving in the stacks.

SM: There is potential for creating hanging garment storage in the stacks, for garments that can withstand appropriate hanging storage. There may be more room to install a textile rack rather than trying to find additional spaces where more boxes can be balanced on top of boxes.

SB: Artifacts storage in the stacks is very tricky, particularly with oversized items. In order to get ideas, I have found myself looking for images online. I used the Google search engine, putting in terms like "oversized artifacts collection storage" and "archival storage artifacts," and I was able to find many useful images on blogs and Pinterest pages of conservators and collection managers. These were either photos they took of their own storage solutions or photos they took while visiting other people's labs, which they posted online. It would be great to be able to access that kind of visual reference information on the Wiki.

Commenter: Both when working at New York University and now at the University of Florida, I would often go out with the archivist on appraisal trips. We would either see a collection that the archivist really wanted or one where [he or she] felt unable to say no to the donor. I would remind the archivist that it is much harder to deaccession something than to not bring it in. With special collections stacks being at the top of their capacity, if a large collection is brought in, something would have to be moved out to off-site storage. I feel that it is a part of my job to communicate with special collections selectors and with donors in order to get in front of collections before they come in.

JJ: One of the challenges that we've had is the unfavorable perception that cherry picking can give to a donor. Even though we may be trying to preserve space on the shelves, it is often a stipulation of the gift that we have to take the entire collection of items. Most of the time, we've had to say that we will take it all and then deal with the space problem later.

Commenter: I won't disagree with that, but I will say that donors like conservators to pay attention to them, since we are behind the scenes people in the library. It is possible to communicate to the donor that if we accept the entire collection, the donor may want to find ways to provide financial support for its preservation and rehousing. Even though I am not working for Development, asking for funding is an opportunity that is on the table if you are present in the room.

Commenter: I have worked at the University of Kansas for a long time and have a great relationship with the curators. Which is why I feel that I can ask the kinds of questions about selection that may transcend the traditional role of the conservator. It is important to know what the value of the item is to the overall institutional collection before spending the time to construct a labor-intensive fancy box for it. With the prevalence of the More Product Less Process approach, I find that the curators are often accepting collections without having the opportunity to find out precisely what is there. Moreover, we often have student workers processing collections, so the tough questions about selecting and editing do not get asked.

OTHER TOPICS

Commenter: Question for Deborah Howe. When you host a workshop, who do you open it up to? The whole library or the whole campus?

Deborah Howe: Our aim is to open the workshops to other conservators. That is our main focus. We really want colleagues in our area to come and participate. The only workshop that I mentioned, which was not marketed to conservators, was the one taught by the university professor. The rest are for our colleagues in the field. We want to share the wealth, so to speak.

Commenter: Question for Suzy. When and how can we get our hands on your videos?

SM: I was expecting somebody to ask me that. There is a reason I haven't put them up on the web. I had incorporated other people's materials into my videos, so I didn't feel comfortable posting them online without asking for permission first. For fair use in a classroom setting, I thought it was okay. I also need to re-edit them. I would like to make shorter versions of these videos and to share them in the future.

ANGELA ANDRES
Special Collections Conservator
University of Kansas
Lawrence, KS
andresa@ku.edu

SOFIA (SONYA) BARRON
Collections Conservator
Parks Library
Iowa State University of Science and Technology
Ames, IA
sbarron@iastate.edu

ANAHIT CAMPBELL
Book Conservator
University of Wisconsin-Milwaukee
Milwaukee, WI
anahitmarina@yahoo.com

Less of You, More of My Ancestors: The Conservation Treatment of Polynesian Barkcloth

INTRODUCTION

The robust library preservation program and leadership in the creation and management of digital resources of Cornell University Library (CUL) promote better access to collections for instruction and research by conserving original materials and building and maintaining digital collections. In fall 2016, CUL's Conservation Lab was contacted by the College of Human Ecology, Department of Fiber Science and Apparel Design (FSAD), to treat a collection of barkcloth from the Cornell Costume and Textile Collection in preparation for digitization. Barkcloth was the subject of the author's final project for the graduate certificate at the University of Iowa Center for the Book (UICB). At that time, the culture and history of Polynesian barkcloth, its methods of manufacture, and conservation practices were researched, and a large Tongan barkcloth stored at the Research and Production Paper Facility (University of Iowa, Oakdale Campus) was conserved and donated to the University of Iowa Libraries Special Collections. The research completed for that project, in part presented here, significantly informed and directed the recent treatment at the CUL Conservation Lab.

ABOUT THE COLLECTION

The FSAD collection includes more than 10,000 items of apparel dating from the 18th century to the present, as well as a substantial collection of ethnographic textiles and costumes. The goal of the FSAD's digitization request was twofold: to create a complete visual record of the barkcloth collection for the first time and to add the collection to the Cornell Costume and Textile Collection's online database. The result of this initiative would increase access to the fragile barkcloth by students and scholars.

The 12 pieces of barkcloth brought to the Conservation Lab for this project had origins throughout Polynesia. Together they represent at least four of the islands (Fiji, Hawaii, Samoa, and Tonga), with a handful listed as "unknown" origin. Known information about the circumstances of accession and history prior to acquisition is noted in their catalog along with a brief description and additional relevant information acquired at the time of accession—for example, "This was made by a Samoan princess and presented many years ago to Commander W.E. Sewell of the U.S. Navy" or "no information, from Hawaii, very old...Donor: Mrs. Edward Devereaux…received by her father Mr. E.R. Embree, who was a Rockefeller foundation official. Tapa cloth gotten when family lived in Hawaii."

TREATMENT OBJECTIVE

The condition of each piece of barkcloth varied significantly; however, the main concerns that affected the long-term preservation of the pieces and presented obstacles to quality image capture were shared by most. Folded and rolled storage left stubborn horizontal and vertical folds in the support, creating shadows and obscuring design elements. Flaking dyes, brittle fiber supports, tears and breaks, and oversized dimensions made transport and image capture in a small studio space both cumbersome and a risk for potential further damage. The barkcloth in their current condition could not be used for instruction or accessed by researchers. The treatment objectives were to enhance the long-term preservation of the barkcloth through sympathetic conservation treatment, particularly the stabilization of weakened areas in advance of digitization, and to provide a storage solution to prevent risk of further damage.

APPROACH

Taking the time to fully understand a collection is a necessary initial step in any conservation treatment. Familiarity with the raw material helps predict how the item will react in treatment, over time, and in different environmental conditions. Awareness of historical and cultural significance reveals

Independent Submission, 2017

use and value, both past and present. Knowledge of manufacture processes explains observable characteristics, helps identify qualities of historical and artifactual significance, and may even suggest the place of origin. Consultation with literature and colleagues identifies treatment practices, presents options, and informs treatment decisions.

THE RAW MATERIAL

The production of barkcloth, also called *tapa*, was once practiced widely throughout the Pacific, eastern Asia, and Africa. Among the Pacific Islands, it was known to the natives in their own languages: *siapo* (Samoa, Futuna), *ngatu* (Tonga, Uvea), *ahu* (Tahiti), *masi* (Fiji), and *kapa* (Hawaii). As the name suggests, barkcloth is a cloth-like material made from the inner bast fibers of select plants. The most prevalent fiber source throughout the Pacific was the *Broussonetia papyrifera* of the Moracaea family, more commonly known as paper mulberry (fig. 1). Depending on the geographic region, other varieties of the Moraceae family were also used, notably the *Artocarpus* (breadfruit) and the *Ficus* (fig and banyan) (Neich and Pendergrast 1997). Additional sources of fiber were obtained from the poison tree (*Antaruis toxicaria*) in the far eastern tropics and the Mamaki (*Pipturus albidus*) in Hawaii (Leonard and Terrell 1980). Each fiber produced a cloth of its own color, quality, and fineness. Manufacturing practices and decorative techniques produced further variations. Traveling with Captain James Cook at Tahiti in July 1769, Joseph Banks, the expedition's botanist, wrote in his journal (Hooker 1896), "of this thin cloth they have as many different sorts almost as we have of linen; distinguishing it into different fineness and the different materials of which it is made" (Brigham 1911, 10; Leonard and Terrell 1980, 22).

Fig. 1. Paper mulberry at the Research and Production Paper Facility, University of Iowa, Oakdale Campus, 2012.

CULTURAL SIGNIFICANCE

Paper mulberry does not grow natively on the Pacific Islands but was transported there by the ancestors of today's inhabitants when they began to migrate from the Asian mainland 7000 to 9000 years ago (Ewins 1987). It was among the items of necessity (food, fresh water, livestock, and plants) selected for their sea voyage and needed upon arrival for settlement. Transporting paper mulberry required great care, with its survival depending upon shelter from the salt water of the ocean and the use of fresh water to keep it alive (Ewins 1987; Meyer 1988). This was not a risk-free undertaking, suggesting the significance of both the plant and the material made from it to the people who made the effort to bring it across such vast distances.

Additionally, the environmental conditions of the islands varied, some being more favorable for growth than others. Orientation to the trade winds, rainfall, elevation, and soil composition all played a role in the vegetation. For example, among the islands of the Tongan archipelago are the raised coral islands of the eastern chain, and those in the west formed by volcanic action. Those in the east have greater elevation, receive an ample amount of rain, and have soil composed of a sandy coral base and volcanic ash. These characteristics provide an environment in which paper mulberry can grow in abundance and a location that supports manufacture (Kooijman 1972, 297).

Historically, the communities of women were responsible for the manufacture of barkcloth. Men played an indirect role, and the degree of their involvement varied by island. They were responsible for making the implements needed for their manufacture—the wooden beaters and anvils, carved designs on bamboo stamps, and wooden printing boards. The women of the village were responsible for harvesting of the bark, beating and manufacture of the cloth, preparation of the dyes, and construction of the vegetal (pandanus leaves, coconut midribs, sennit, etc.) printing tablets used in their decoration.

USE

Traditional uses of barkcloth range from utilitarian household purposes (curtains, room dividers, bedding, mosquito nets, bandages, candle wicks, and clothing) to ceremonial (burials, deaths, births, taxes to the chiefs, and offerings to the gods). Certain colors and styles were reserved for nobility. If one were aware of these cultural nuances, one would be able to gather cultural significance by sight.

MANUFACTURE

Understanding the manufacturing processes can inform our observations about these artifacts, indicating reasons for current conditions, predicting future concerns, identifying provenance, and serving as a visual witness to the methods used by practitioners. The fundamental steps of barkcloth production were shared; however, the specific processes involved varied by location. Harvesting, preparation, beating, implements used, decoration techniques, and patterns each contribute to the unique qualities and characteristics that make one place of origin distinct from another.

In the most general terms, the practice was to harvest the fiber and separate the outer bark from the inner bark. The inner bark was then cleaned and beaten on a wooden (or stone as sometimes used in Hawaii) anvil, often hollowed for resilience and musical resonance. The cleaned narrow strip was beaten until it became a soft, widened, thin piece of cloth expanding in width from about 2 in. to 14 to 18 in. Larger pieces of cloth were made by overlapping the edges of the smaller beaten strips and adhering them together with a starch adhesive (e.g., arrowroot). Thickness was determined by the number of layers, usually two, and more for items such as bedding. With the exception of traditional Fijian cloth, the practice was to lay the upper layer perpendicular to the lower.

The growing season and cultivation of plants used for barkcloth were well defined. Throughout the islands, the growth of paper mulberry was monitored; attention was given to cutting the off-shoots of small branches that would result in holes in the harvested bark. The stalks were cut when the plant was 12 to 18 months old, about 9½ to 11½ ft. in height, the "thickness of a man's thumb" (Kooijman 1972, 213), or when the "green bark becomes silvery white" (Kooijman 1972, 299).

The color and character of the undecorated cloth were determined by the fiber chosen and the subsequent manufacturing processes. In fact, the initial stages of the harvest and preparation of the bast fiber were very much akin to those practiced in Japanese papermaking—the ideal fiber being pristine and free of blemishes. Only fiber of this quality would produce the finest sheet of *washi*. Speaking of Hawaiian *kapa*, Samuel Kamakau writes, "well-made tapa must be cleaner than moonlight; clearer than snow on the mountains" (Kooijman 1972, 102). Steaming, retting, smoking, soaking, and drying each further influence color and quality of the barkcloth produced. In addition, the way each of these steps was carried out produced further variation. For example, retting in mud versus retting in salt water, soaking the bast fiber in fresh water rather than salt water, and the duration of the soak produced different results (Doyal 2001).

Various beating methods were found throughout the islands, including folding and beating in bundles, beating strips individually, and felting. The sides, save at least one, of the wooden mallets (beaters) (fig. 2) used to beat out the bast fibers were grooved. The grooves of each side often varied in width and depth. Initial beating was done with the coarsest side of the beater, moving progressively toward the smooth. In Hawaii, this process was at times taken one step further—a final beating using a beater with a carved surface (fig. 3) imparted texture and pattern into the finished cloth (fig. 4).

As the technology spread throughout the islands, influence from one island to the next can be seen both in shared methods of manufacture and visibly in characteristics of the cloth decoration. Despite these commonalities, distinct practices, patterns, motifs, and the overall look to a finished cloth developed on each island. The designs and patterns were applied by a variety of methods: freehand, stencils, stained with local dyes, smoked, and/or printed (fig. 5).

Before the introduction of synthetic dyes, native plants were used to create dyes and impart color to a finished cloth. It is no longer known exactly how these dyes were made, but it is known that they were often made from the bark, fruit, and roots of local flora—for example, brown from the bark of the candlenut tree, reddish brown from the bark of the *Bischofia javanica,* black from the soot of burnt candlenut kernels, and yellow from the root of the *Curcuma viridiflora* (Kooijman 1972, Appendix: Table E).

The use of vegetal design tablets to transfer patterns or designs onto the cloth was practiced in Samoa, Tonga, and Fiji. These tablets, called *upeti* in Samoa, *kupesi* in Tonga, and *kupeti* in Fiji, were constructed of two layers of pandanus or

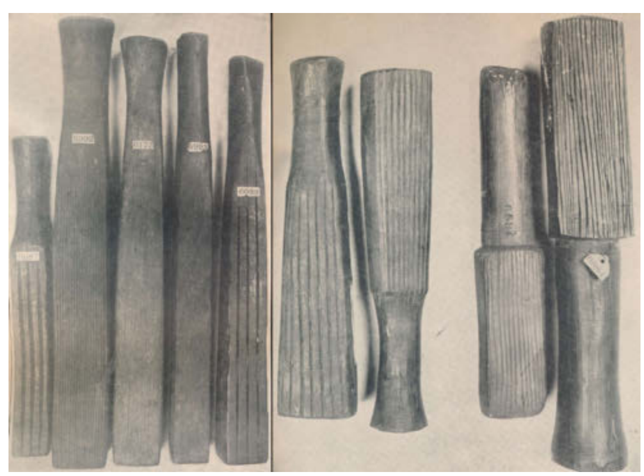


Fig. 2. Left: Tahitian beaters with grooved parallel sides. Right: Flared beaters (Tonga) and irregularly grooved beaters (Solomon Islands). Images from Brigham (1911, Appendix: Plates 6 and 7).

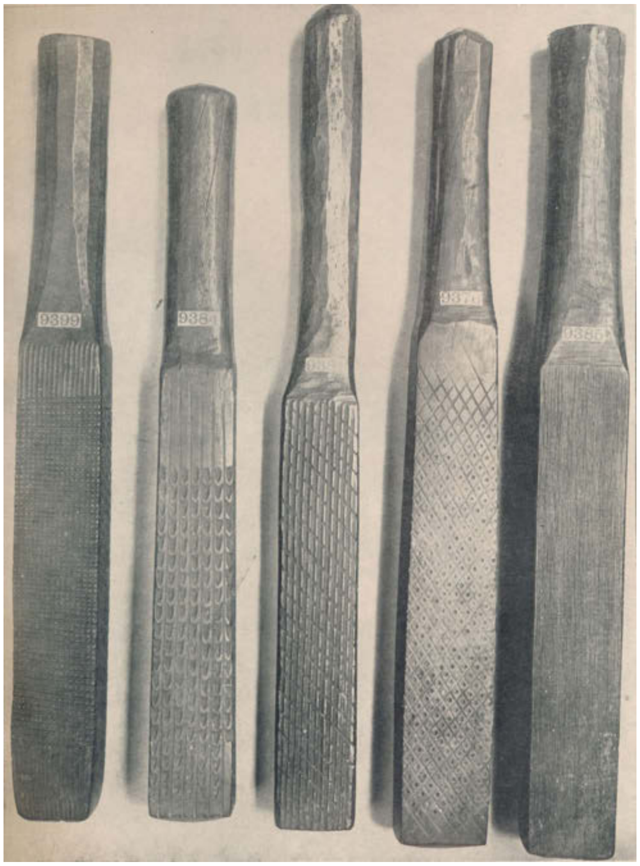


Fig. 3. Hawaiian beaters carved with patterns to impart texture. Image from Brigham (1911, Appendix: Plate 3).

coconut leaves. The top layer carried a relief pattern most commonly created from pandanus leaves, sennit, coconut midribs, bamboo, and hibiscus fiber. A rubbing technique was used to transfer the relief pattern to the beaten cloth (figs. 6, 7).

Fig. 4. Left: An undecorated piece of barkcloth from the Cornell FSAD collection. Right: Detail showing the texture imparted by a patterned beater.

The use of vegetal design tablets began to decline in the early 20th century after the introduction of metal tools proved the use of carved wooden boards a more durable alternative. Arkinstall (1966) notes this change in her graduate thesis, quoting Margaret Mead writing of Samoa in 1930: "But so well defined is the province of tapa making as women's work, that men have not exercised their imagination on the carving of these boards." Arkinstall further adds, "Thus, the patterns on the rubbing boards have become somewhat stereotyped. The women are not happy with the situation, but since wood carving has traditionally been men's work, they do nothing but sit by as their patterned tapas become less and less interesting" (Arkinstall 1966, 119).

Within the Cornell FSAD collection are examples that clearly display the use of vegetal tablets and carved wooden boards (figs. 8, 9). Dyes of a darker color (black, dark brown, brownish red) were often applied freehand to the recto, highlighting chosen aspects of the design. The patterns from the vegetal printing tablets and carved wooden printing boards are more visible on the verso, making it possible to identify the plant material used to create the relief, repeating patterns, and number of tablets used to create the design. This information perhaps can assist in identification of origin or reconstruction of the manufacture process.

SIGNS OF DETERIORATION

Mechanical stresses, light exposure, fluctuations in relative humidity, biological agents, and pollutants each contribute to further deterioration of barkcloth. Exposure to light weakens fibers and contributes to color fading. Relative humidity that is too low or fluctuates causes the fibers of the cloth to become brittle, weaken, and break down. Dust can cause stains, attracts insects, and promotes mold growth (Bishop Museum 2012). As cellulose breaks down, pH decreases, increasing the potential of acid deterioration (Hill 2001).

The dyes, pigments, resins, gums, paints, and oils used to decorate and finish barkcloth can become faded and brittle over time. As a result, the media begins to flake. Consequently, the cloth below the colored area will also become brittle and stiff—breaking, tearing along folds, or separating along the grain, leaving holes (Hill 2001) (fig. 10). Specific to Samoan barkcloth, brittleness, insect damage, and acid deterioration are prevalent due to the use of arrowroot paste to join sections and the use of the acidic dye made from *Bischofia javanica* (Bishopwood) (Rose et al. 1988).

In traditional methods of island storage, large pieces of barkcloth were stored in rolls among the rafters of the home, often in areas affected by cooking smoke. Although the cooking fire kept the cloth dry and free of mold and the aldehydes in the wood smoke acted as a preservative against biodeterioration, the exposure to smoke allowed for the collection of soot, which leads to deterioration over time (Hill 2001).

Fig. 5. Methods of decoration found among the Cornell FSAD collection. Left: Freehand. Center: Stenciled. Right: Freehand over a design transferred from a carved wooded board.

There are, however, parts of the manufacturing process that inherently strengthened the quality of the cloth produced. Steps taken during the prebeating processes and the nature of the beating and drying processes each involve aspects that promote the longevity of the cloth.

The practice of soaking or steeping the bark for several hours prior to beating encourages a stronger and more flexible cloth. As a result, bacteria and fungi from fermentation cause the plant cell wall material to break down, allowing the pectin and hemicelluloses that normally stabilize the cell walls of the living plant to be redistributed during soaking. Because of this redistribution, the resulting cloth is more flexible. The pectin and hemicelluloses that remain in place add strength to the fibers and, consequently, to the cloth (Hill 2001).

During beating, the grooves on the face of the beater spread the fibers and alter their parallel orientation to one that is angled and interlocking, as well as allow excess water and air to escape. This interlocking, rather than parallel, orientation is stronger and less prone to lateral tears that most often occur parallel to the grain of the cloth's fiber (Hill 2001).

In the drying process, the barkcloth is stretched out in the sun. The high UV content of the tropical sun stunts the growth of micro-organisms (Hill 2001). It is the following stages of decoration, use, and storage conditions that most contribute to deterioration.

BACKGROUND RESEARCH ON CONSERVATION PRACTICES

Published research from the 1980s and 1990s (Rose et al. 1988; Wright 2001) narrating conservation projects of barkcloth collections at six separate institutions (Exeter City Museums, Manchester Museum, British Museum, Harvard Peabody Museum, Queensland Museum, and Bishop Museum) provided an overview of the needs of collections varying in scale and scope and offered solutions to meet these needs. The conservation projects described by these reports have ranged from the study of one specific item to large-scale renovation projects involving the rehousing of entire collections. En masse, the research identified potential signs and

Fig. 6. Vegetal printing tablets, Field Museum of Natural History, Chicago, 2012.

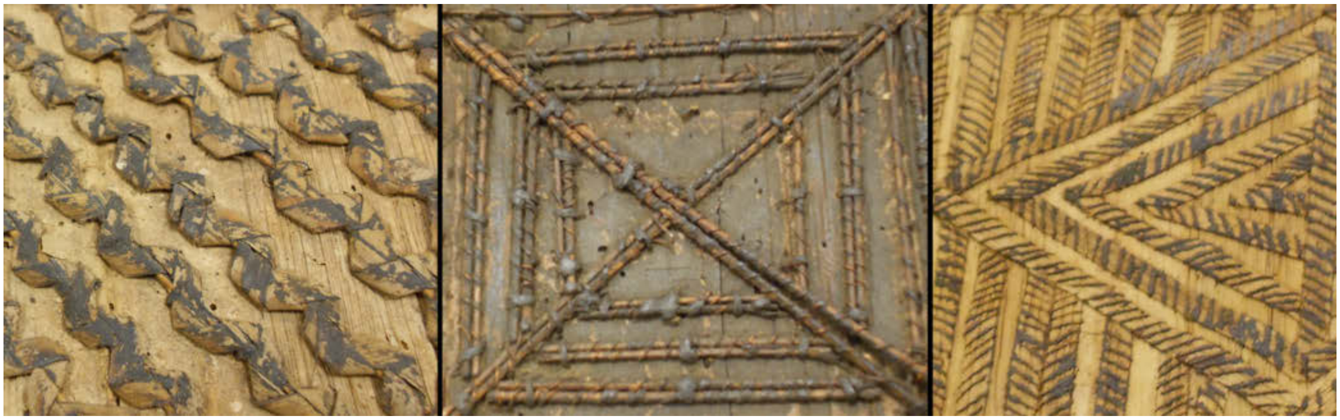


Fig. 7. Details of vegetal printing tablets, Field Museum of Natural History, Chicago, 2012.

causes of deterioration and discoloration, discussed treatment options, and addressed storage concerns.

Although the treatment of barkcloth is unique to each item, the organization and general measures taken to determine individualized treatment shared commonality among the reporting institutions. The goal of renovation projects was to preserve and render the collection more safely accessible to study by assessing the current condition, providing necessary treatment, and developing appropriate storage. Projects focused on scientific analysis aimed to identify catalysts of deterioration.

The recent treatment at CUL's conservation lab was driven by the need to address condition concerns to safely and successfully digitize the 12 pieces of barkcloth and improve their condition for use in instruction and research. The approach taken by CUL follows that of a renovation or relocation project—the barkcloth needed treatment prior to digitization and a storage solution that served the needs of preservation and accessibility. The result of digitization would be threefold: expansion of the online catalog, improved condition of the original cloth, and updated storage solutions—each facilitating use in instruction and research.

TREATMENT APPROACH

The research and conservation efforts referenced previously differed in scope and purpose and therefore did not follow the same sequence of steps. However, they do provide an approach outline when developing a conservation treatment

Fig. 8. Example of the use of a vegetal printing tablet in the Cornell FSAD collection. Detail of recto and verso. The patterns seen on the verso are indicative of the use of a vegetal printing tablet. The origin of this cloth was labeled as "unknown." Considering that this method was used most notably in Samoa and Tonga, and the designs are similar to known cloths of each location, it is likely that one or the other is the place of origin.

Fig. 9. Example of the use of a carved wooden board in the Cornell FSAD collection. Detail of recto and verso. The patterns seen on the verso are indicative of the use of a carved wooden board. The origin of this cloth was labeled as "unknown." Considering that this method was used most notably in Samoa and Tonga, and the designs are similar to known cloths of Samoa, it is possible that Samoa is the place of origin.

Fig. 10. Left: Flaking dyes. Center: Loss. Right: Tears.

plan. Renovation and relocation projects began with description and condition surveys to address the safety of transport and treatment needs of the items. Description surveys considered size, patterns and designs, colorants, and fiber, whereas condition surveys noted physical qualities including dirt, folds, tears, brittleness, discoloration, sections joined, texture, and pH. Once these initial assessments were completed, storage options could be considered. In renovating, storage could be more tailored to specific needs; in relocating, storage options were directed by available space.

The condition of the item determined subsequent treatment, which often included photodocumentation; surface cleaning; humidification; flattening; mending; and, in rare cases, deacidification and lining. Humidification allowed brittle pieces of barkcloth to relax and be unfolded. Once unfolded, creases and folds could be flattened and the cloth reshaped under light weight. The surface could then be more thoroughly cleaned if needed. For extremely brittle pieces, a deacidification process was considered to increase the pH, stop further acid deterioration, and extend the life of the cloth. Torn areas were then mended; if necessary, the barkcloth could be offered the additional support of a tissue lining. The condition of the item was reassessed after treatment before being stored.

The literature offered insights regarding the appropriate level of treatment without compromising the historic integrity of these ethnographic items. Perhaps the most valuable succinct words of guidance were those shared by a colleague: "less of you, more of my ancestors." Because many of the pieces of barkcloth from the Cornell FASD collection were oversized, they would need to be rolled both for final storage and for transport to and from the digitization studio. This would mean needing the strength to withstand being rolled and unrolled multiple times both during the imaging process and afterward for use in instruction and research.

In addition to this stability concern were other factors that needed consideration—the inherent causes of deterioration rooted in the barkcloth's history, extending from the time of manufacture and the processes involved, to use and the environmental conditions of previous and present storage.

OVERVIEW AND IMPLEMENTATION OF TREATMENT METHODS

Although the approach and treatment steps were similar, the differences in methods of humidification, cleaning, and tissue repair provide options in conservation treatment. A brief description of methods found in the literature are referenced for each treatment step discussed in this section. The method selected for the Cornell FASD collection follows.

CLEANING

If the condition of the item permitted, surface cleaning prior to humidification was used to remove any surface dirt that would contribute to further deterioration or embed into the fibers when moisture was introduced. The condition of the item dictated the method of cleaning used. These included one or a combination of vacuuming through a screen, the use of a soft brush, or the use of a vulcanized rubber sponge.[1] The use of latex-free cosmetic foam wedges, now commonly used in conservation practices, was not mentioned in the literature but may provide another option for reducing surface soil from barkcloth collections, being less abrasive than vulcanized rubber sponges.

Previous studies reported that when using a brush, a vacuum should be used in conjunction to remove the dirt as it is loosened with the brush; otherwise, the loosened surface dirt is only spread across the item and further ingrained (Norton 2012). In the presence of mold, the spores can be removed with a dry, soft-bristled natural brush. Although staining will remain, the primary concern is to remove the spores, thus preventing future growth (Bishop Museum 2012).

The barkcloth from the Cornell FSAD collection were not heavily soiled. Some items were very fragile overall, with flaking media, tears, and loose fiber; others contained only brittle areas. In these cases, a sponge or a brush directly in contact with the surface of the item would be too abrasive, risking further damage and loss. For this collection, surface soil was reduced using a Nilfisk HEPA vacuum through a screen (fig. 11).

HUMIDIFICATION

Humidification methods[2] ranged from localized humidification under dampened blotter to makeshift chambers constructed to accommodate size and quantity, with care taken to monitor relative humidity of the collections. Attention was directed toward the presence of fugitive dyes, consideration of salt-retted and oiled cloths, and the effects of drying. Because humidification introduces moisture to the object, items decorated with dyes were tested in discrete areas to determine dye stability. Those pieces that have been salt retted allow for the possibility of salts being drawn out during humidification, whereas those that have been oiled prevent the use of humidification and water-soluble adhesives in treatment. Ironically, it is the effects of the oils that lead to acidification and embrittlement, and, consequently, the need to humidify, making treatment challenging (Doyal 2001).

Fig. 11. Vacuuming with a Nilfisk HEPA vacuum through a screen allows for the reduction of surface soil, avoiding direct contact with the item.

The goal of humidification among the Cornell FSAD collection was the reduction of deep wrinkles, creases, and folds that have resulted from folded and rolled storage. Each barkcloth was humidified for approximately 20 to 30 minutes between felted Gore-Tex (sprayed with filtered water), allowing a controlled use of water vapor to relax the fibers (fig. 12). Pieces of barkcloth that could not initially be safely unfolded to their full dimension were unfolded slowly during humidification as the needs of the barkcloth directed. The barkcloth pieces were then placed between heavy-weight oversize blotters and allowed to dry under very light weight to maintain the naturally textured quality of the cloth. Frayed and undecorated edges were addressed with local humidification.

The dimensions of most of the barkcloth allowed for overall humidification at one time. However, there were not adequate space or humidification materials to accommodate the largest barkcloth in this way. Instead, this piece was humidified as follows. Half of the item was placed between felted Gore-Tex (sprayed with filtered water), whereas the remaining half was kept rolled on a tube. The humidified half was then dried under light weight. Once dry, the process was repeated for the other half. With both halves initially humidified and flattened, the workbench surface was extended with large Plexiglas sheets and the whole barkcloth was unrolled and laid flat between blotters. Light weight provided even and continued resistance to the reformation of wrinkles and folds.

TISSUE REPAIRS

Tissue mends serve to bridge separated areas, fill losses, and stabilize and strengthen weakened areas. Ideally, mends should be placed on the back and be invisible to the eye. Separated fibers that required additional support and alignment prior to

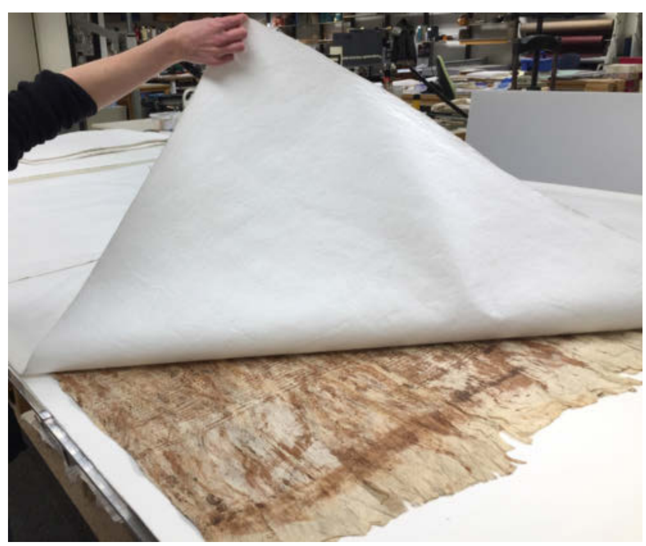


Fig. 12. Each item was humidified between felted Gore-Tex until the fibers were relaxed enough for the item to be fully unfolded and then dried under light weight to restrict the reformation of stubborn folds.

Fig. 13. Previous repairs. Left: Holes that occurred at the time of manufacture during beating were patched with small pieces of barkcloth. Right: Similarly, later repairs were made with recycled pieces of barkcloth. In these instances, the previous repair was of historic value and left in place.

mending were given temporary mends on the front, stabilizing the item so that it could be fully mended on the back (Rose et al. 1988). Losses were filled from the back with toned tissue with a water-torn feathered edge. Care was taken to distinguish between losses due to natural or ethnographic causes rather than deterioration. These ethnographic marks were left untouched, preserving the integrity of the item (fig. 13).

The literature cited testing of potential tissues and adhesives for repair. The Queensland Museum's report discussed a comparison of tissue materials, color matching, and adhesive tests. Four possible materials were chosen for testing: (1) kozu-shi (for being the same fiber as many barkcloths and its proven use in paper mends), (2) barkcloth (for its compositional compatibility), (3) Reemay (for its use in textile repairs and chemical stability, flexibility, and texture), and (4) spun-bonded polypropylene (for its use in ethnographic conservation and availability in neutral colors). Tapioca starch, wheat starch, methyl cellulose, and Klucel G were tested as potential adhesives with each of the sample tissues mentioned earlier. Ultimately, the polyester Reemay used with tapioca starch was chosen for its flexibility with relative humidity, adhering qualities, and visual compatibility (Hill 2001).

The Peabody Museum opted to use a mulberry tissue and aqueous adhesives (not specified) (Holdcraft 2001). Similarly, the Bishop Museum also chose to mend with a variety of Japanese tissues (usumino, sekishu, tengujo, kizukishi). In addition to being among the same fiber source as the barkcloth, the long thin fibers of Japanese tissues adhere well without adding bulk. Rice starch paste was chosen as an adhesive for its good tack, flexibility, water reversibility, and ability to be toned with water-soluble acrylic pigments (Rose et al. 1988).

The author's previous research at the UICB repeated this process—choosing tissues and adhesives based on use among other collections and determining the most suitable by comparison of testing results. At that time, wheat starch paste and a heavier-weight tengujo proved most compatible. For the Cornell FSAD treatment, tengujo was suitable for stabilizing the torn and frayed undecorated borders, but for large interior tears, areas of brittle cloth, and flaking media, a heavier tissue was needed. For these areas, an assortment of Japanese tissues (kozo, tengujo, and usumino) was used with wheat starch paste. The literature on barkcloth production mentions only the use of adhesives derived from plant-based materials (cassava, arrowroot). Of the adhesives noted in conservation literature, wheat starch and rice starch paste were the most closely related to the adhesives, if any, used in barkcloth manufacture. Wheat starch was chosen for this treatment not only because it was accessible and familiar but also because it has proven outstanding working properties, longevity, and reversibility.

The mending and stabilization needs of the CUL collection varied from fragility imparted by numerous small lateral splits in the barkcloth, areas of loss, and areas of potential loss presenting instability (fig. 14) to a large central vertical tear (figs. 15a, 15b) extending nearly the entire length of the cloth (7 ft. 11 in.). The hand-applied dyes surrounding this latter area were extremely brittle and flaking. Subsequently, the cloth on either side of the tear was also brittle, shredded, and mangled. Temporary reversible bridge mends (Japanese tissue with a thin coat of wheat starch paste) (fig. 15c) were applied on the front to ensure that the design was aligned correctly. The cloth was then rolled, unrolled to have the underside face up, and mended

Fig. 14. Top row: Before treatment, recto and verso. Bottom row: After treatment, recto and verso.

Fig. 15. (a) Central vertical tear extending nearly the full length (7 ft. 11 in.) of the cloth. (b) Close-up of the central vertical tear extending nearly the full length of the cloth. (c) Temporary reversible bridge mends were placed on the recto to hold the cloth in position and ensure proper alignment.

on the verso (fig. 16). Once the mends on the verso were dry, the temporary mends were removed with a light application of filtered water.

LINING

None of the items in this collection needed to be lined; both the literature and colleagues consulted advised that this be used only as a last resort. More information about the circumstances and procedures of this option can be found in the literature[3] (Gottschlich et al. 2015).

STORAGE

In assessing storage options, the realistic often replaces the ideal. Depending on size and condition of the item,

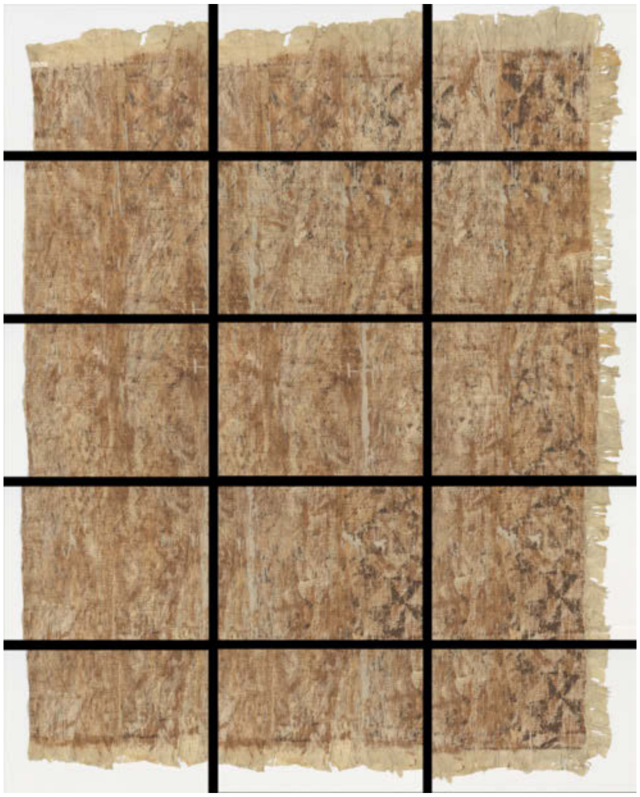


Fig. 16. Each side of each item required multiple shots (12-15 per side) that would then be stitched together using Photoshop (see fig. 17).

the institutions conducting renovations and relocations of their collections had to consider what was most beneficial to the barkcloth while also keeping within allotted limits of budget and available storage space. The preferred and most ideal, although often impractical, is to store the barkcloth flat (Holdcraft 2001) with equal weight distribution (Rose et al. 1988). The least desirable storage is obviously one that facilitates further damage. Folding and stacking cause creases, uneven stretching, breakdown of fibers, and wear along folded edges (Rose et al. 1988). For larger items that must be folded to fit a storage space, folding over a soft support is an option. These items can then be stored individually or in small groups in stackable, lidded boxes (Holdcraft 2001). Rolling is an option for larger items as well, but depending on the fragility of the item, rolling may increase the potential for the flaking of media on delicate or heavily painted pieces (Rose et al. 1988; Murray and Johnson 2001) and add stress to seams and sheets of multilayered cloths (Rose et al. 1988). Although the roll saves space, it also limits accessibility to the researcher, and if used frequently, the rolling and unrolling can potentially lead to further damage (Rose et al. 1988). If rolling is the chosen option, it should be rolled with interleaving to prevent rolling onto itself (Holdcraft 2001; Murray and Johnson 2001). In the presence of mold, interleaving serves as a barrier between areas contaminated by mold and those that are not. If the ideal storage conditions cannot be met, the main priority is to provide the item with the storage format that best safeguards it from further deterioration and damage.

Among the Cornell FSAD collection, the pieces of barkcloth that fit in folders were stored flat in archival paper folders in flat file map cases. The remaining oversized pieces were rolled on 4.5-in.-wide archival tubes covered with Ethofoam (for cushioning) and a polyester film cover (a barrier between the barkcloth and the Ethofoam). The barkcloth was rolled face up with Hollytex interleaving (spun polyester web). An additional cover of polyester film was rolled around the tube to protect from dust. The tube was labeled with a thumbnail image and catalog information for identification and to limit unnecessary unrolling. The physical collection, now stabilized and more safely stored in a secure climate-controlled environment, is available for research and study alongside the digitized images online.

DIGITIZATION

Published accounts of the digitization of barkcloth collections were not readily found in the literature. The equipment and methods described in the following were those used by the Digital Media Group at CUL. Priority was given to safety in transport and handling, as well as quality of image capture. The Conservation Lab is located on the lower level of Olin Library; the digitization studio is located on the first floor. Limited studio space required each piece of barkcloth to be transported and captured digitally one at a time. Each barkcloth was rolled onto a padded archival tube and hand carried to the digitization studio. Due to oversized dimensions of some of the barkcloth, pieces were imaged on the floor with the camera above on a motorized column from above, capturing one section at a time. A live view on the computer software helped to accurately capture sections so that they could be successfully stitched together in Photoshop. Conservation and digitization staff worked in teams of two in tight quarters during the digitization process to handle the barkcloth. This involved partial unrolling, repositioning under the camera, and rerolling to access the next section. An oversized piece of corrugated plastic board was used as a support and allowed for the cloth to be easily shifted as needed and protected from direct contact with the studio floor. Each barkcloth was imaged recto and verso, with the oversized pieces requiring several images; therefore, digitization could take an hour or more per barkcloth.

A Phase One IQ3 100-megapixel digital back and Digital Transitions DT RCam were used for image capture. This equipment produces an 11,608 x 8708 pixel raw image that can be processed into many different formats. Although the setup for each image required calibration and focus of the camera and time to safely position the barkcloth, image

Fig. 17. Left: After treatment recto. Right: After treatment verso.

capture is quite fast with this method. Four LED lights (Lite panel Astra 1x1) were used for lighting. These panels create an even light (cool and non-UV) with soft boxes and diffusers attached. Calibration with the DT RCam provides an accurate reproduction. The camera is able to capture an area of 40 in. per shot. This meant that the largest items required 12 to 15 shots per side (fig. 16). Each image file is 289 MB. The individual images are then stitched together in Photoshop. The composite image is approximately just over 1 GB in size (Ingall 2017) (fig. 17). The digital images were uploaded to a searchable media management system that supports source files and associated data according to the National Digital Stewardship Alliance's suggested guidelines.

The resultant digital image captures the design, texture, and manufacture characteristics of each cloth in stunning detail. The online collection can be used for instruction and research, facilitating comparison with other collections worldwide.

CONCLUSIONS: THE IMPORTANCE OF CONSERVING BARKCLOTH

Because production of barkcloth has ceased on most of the islands, the methods of production originally used by the ancestors of today's inhabitants are not wholly known. The effects of European influence and missionary initiatives began to heighten during the 18th and 19th centuries. The introduction of synthetic dyes in decoration of the cloths and the replacement of vegetal design tablets used in Tonga, Samoa, and Fiji with carved wooden boards are only two examples.

Primary accounts from the 20th century provide a record of the noticeable change occurring in barkcloth production throughout the Pacific Islands. Writing in 1911, W. T. Brigham notes that "Samoa still continues its rather coarse *siapo* making, but it is mainly for exportation as a curiosity" (Brigham 1911, 3). Arkinstall's research (1966) found the production of *kapa* in Hawaii had ceased by 1890. Dard Hunter, writing of his travels to the Pacific islands in 1926, confirms this, noting that "in this highly commercialized locality not a vestige of anything relating to this age-old industry remains, and, aside from exhibits in museums, it might never have existed" (Hunter 1943, 30). While barkcloth was still being made at this time in Savaii, British Samoa, and Taviuni of Fiji, Hunter found no production akin to its original practice, and this had been the case for more than 100 years, since the early 1800s. It was not until arriving to the islands of Tonga that he found barkcoth being made in a manner the least pressured by modern influence. As of the mid 1920s, Tonga was the only island that produced barkcloth for native uses and not for the tourist market (Hunter 1943). In 1984, 58 years later, Adrienne Kaeppler of the Smithsonian Institution noted that of the Polynesian Islands, only Tonga, Samoa, and Fiji were still producing barkcloth in some fashion (Pritchard 1984). With few exceptions, the production and high cultural regard of barkcloth has waned, and current manufacture is produced in lesser quality for the tourist market. The indigenous technologies that were once used have been altered and over generations have become lost to unrecorded history and memory.

The available knowledge regarding the ancient production methods of barkcloth is limited. Primary accounts and observations have been provided by sources obtained from Captain Cook's voyages, a few expeditions, and a handful of adventurous scholars (Brigham 1911; Hooker 1896; Wharton 1893). Although these accounts present variations and contain gaps, they are invaluable to the study, preservation, and revival of the craft and culture of the people who practiced it long ago. Because nothing of equal quality is being produced today, conservation efforts to identify the material, environmental, and technological influences responsible for the current condition are necessary to determine appropriate treatments. In preserving these materials, an abundance of cultural, historical, sociological, and artistic information is retained for further research and study of the Pacific Islands and Pacific Island culture. The conservation treatment and digitization of the barkcloth from the Cornell FSAD collection will promote preservation without limiting accessibility and also assist scholars and researchers to use this information to advance knowledge within their field of study.

ACKNOWLEDGMENTS

The author wishes to thank those who have contributed to the both the previous body of research completed at the UICB and those involved in the present research, treatment, and digitization, especially Timothy Barrett, director of Center for the Book, for his encouragement, guidance, and contributions to editing and refining my final project at the UICB, and my supervisor here at Cornell University, Michele Hamill, Paper and Photograph Conservator, who cannot be thanked enough for her continued encouragement and guidance throughout this project, for allowing me the time to pursue further research in preparation for this article, and for her willingness to assume the role of editor. Thank you also to Simon Ingall, Digital Imaging Assistant, Cornell University, for sharing his expertise and facilitating safe and quality image capture. Many thanks also to our international colleagues for sharing their expertise concerning the treatment of these items: Michele Austin-Dennehy and Adrienne Kaeppler at the Smithsonian Institution; Anne Peranteau at Te Papa Museum, New Zealand; Nicole Dela Fuente at Bernice Pauahi Bishop Museum; and Misa Tamura at the University of Glasgow.

NOTES

1. A brush and vacuum were too abrasive for the Manchester Museum collection, disrupting the cloth fibers. A rubber latex sponge proved more suitable. At the Peabody Museum, vacuuming in conjunction with a vulcanized rubber sponge followed by a second vacuuming was used. Other methods included the use of a soft brush, air blower, vacuum, and chemical sponge.

2. Humidification procedures used by each institution:

- *Queensland Museum* (Hill 2001). Using a polyethylene humidification chamber and an ultrasonic humidifier, relative humidity was held at 95% for 24 hours. The barkcloth was unfolded gradually onto two layers of acid-free blotting paper with Plastazote beneath for cushioning. Once fully opened, folds were flattened locally under glass weights lined with acid-free blotter paper for two days, changing the blotter daily.
- *Manchester Museum* (Murray and Johnson 2001). Using a humidity tent and an ultrasonic humidifier and humidistat, the relative humidity was kept at 65% to 70% for 24 to 48 hours. Once fully unfolded, the barkcloth was left for an additional 24 hours. The areas that retained creases and folds were "smoothed" and, when necessary, were placed directly under weight. The flattened and weighted barkcloth was then held for another 6 to 24 hours at 65% to 70%RH. The relative humidity was then reduced to 50% to 55%, allowing the barkcloth to shrink, effectively smoothing out creases or folds. This process was repeated over four to eight weeks, until the item reached a sufficiently flattened state. Large cloths were partially unfolded and flattened, rolled onto acid-free cardboard tube, and unfolded until completely treated.
- *Peabody Museum* (Holdcraft 2001). A local humidification method that weighted a layering of Gore-Tex or Reemay with moistened blotter over the creased areas was used. Once moisture had been introduced, the blotter was removed and the weights remained atop dry blotter.
- *Bishop Museum* (Rose et al. 1988). The barkcloth was placed on fiberglass shelves of an open-frame cabinet enclosed in polyethylene sheeting for 8 to 12 hours. A humidifier was placed on the chamber floor. Once relaxed in the chamber, the tapa was unfolded and flattened on a table covered with acid-free blotter paper. Distilled water was sprayed over, not on, the item. Creases, wrinkles, and folds were flattened by gently pulling the borders of the cloth and, if necessary, weighting them. The barkcloth was covered with blotter to absorb moisture and facilitate drying. Once multiple pieces of barkcloth had been flattened, the stack was weighted with papermaking felts, providing even weight and continued resistance to the reformation of wrinkles and folds.

3. The Bishop Museum's collection (Rose et al. 1988) includes some extremely deteriorated pieces that required additional support beyond what the tissue mends could offer. Their report describes a full lining of tengujo applied to the back of the item. This procedure was done after all other repairs had been made. Tengujo was chosen because of its soft, long, thin, and flexible fibers. These qualities add strength without adding bulk. It is strong enough to mend all weights of tapa and can be tinted without obscuring any marking that may be present. Rice starch paste was chosen as the adhesive because it can be diluted and still maintain its strength. The lining procedure used is as follows. The barkcloth was laid face down on blotter paper that had been covered with a release material. The portion of the barkcloth to be lined first was misted with distilled water. This step is imperative. If omitted, the cloth fibers will absorb moisture from the pasted tissue too quickly, causing stress to both the cloth and the tissue, resulting in restrained expansion and possible tears in the tissue lining that is being placed for stability. Due to its extremely thin nature and fragility when wet, the tengujo was pasted up on polyester and then transferred to the back of the cloth. Once placed, the polyester was removed and the tissue pounded to remove any pockets of air that could potentially result in bubbling. The lined barkcloth was then left to air-dry for a short time. Polyester web, blotter, and weighted glass were applied after this partial drying.

REFERENCES

Arkinstall, P. L. 1966. *A study of bark cloth form Hawaii, Samoa, Tonga, and Fiji: An exploration of the regional development of distinctive styles of bark cloth and its relationship to other cultural factors*. Master's thesis, Cornell University, Ithaca, NY.

Bishop Museum. 1996. The care of tapa. http://www.bishopmuseum.org/wp-content/uploads/2016/04/cnsv-tapa.pdf.

Brigham, W. T. 1911. *Ka Hana Kapa, the making of bark-cloth in Hawaii*. Honolulu, HI: Bishop Museum Press.

Doyal, S. 2001. Condition survey of barkcloth at Exeter City Museums, with particular reference to the African collections. In *Barkcloth: Aspects of preparation, use, deterioration, conservation and display*, ed. M. M. Wright. London, England: Archetype Publications Ltd. 10-19.

Ewins, R. 1987. Bark-cloth and the origins of paper. Paper presented at the First National Paper Conference, Hobart, Australia.

Gottschlich, L., A. Gupta, J. Johnson, and A. Nichols. 2015. Tattered tapa: How a multi-disciplinary collaboration revived a 19th-century Fijian bark cloth. http://resources.conservation-us.org/anagpic-student-papers/wp-content/uploads/sites/11/2016/01/2015ANAGPIC_Gottschlich_etal_paper.pdf.

Hill, R. 2001. Traditional barkcloth from Papua New Guinea: Materials, production and conservation. In *Barkcloth: Aspects of preparation, use, deterioration, conservation and display,* ed. M. M. Wright. London, England: Archetype Publications Ltd. 24-55.

Holdcraft, T. R. 2001. Research, exhibition and preservation of the barkcloth collections from the Pacific in the Harvard Peabody Museum. In *Barkcloth: Aspects of preparation, use, deterioration, conservation and display*, ed. M. M. Wright. London, England: Archetype Publications Ltd. 96-111.

Hooker, J. D., ed. 1896. *Journal of the Right Hon. Sir Joseph Banks, Bart., K.B., P.R.S., during Captain Cook's first voyage in H.M.S. "Endeavour" in 1768-71 to Terra del Fuego, Otahite, New Zealand, Australia, the Dutch East Indies, etc*. London, England: Macmillan & Co. Ltd.

Hunter, D. 1943. *Papermaking: The history and technique of an ancient craft*. New York, NY: Dover Publications Inc.

Ingall, S. 2017. Personal communication. Cornell University, Ithaca, NY.

Kooijman, S. 1972. *Tapa in Polynesia*. Bishop Museum Bulletin 234. Honolulu, HI: Bishop Museum Press.

Leonard, A., and J. Terrell. 1980. *Patterns of paradise: The styles and significance of bark cloth around the world.* Chicago, IL: Field Museum of Natural History.

Meyer, A. 1998. Foreword. In *Tapa: Bark cloth of Oceania*, ed. P. Cusenier. Paris, France: Galerie Meyer. 2.

Murray, C., and E. Johnson. 2001. The conservation and storage of barkcloths at the Manchester Museum. In *Barkcloth: Aspects of preparation, use, deterioration, conservation and display*, ed. M. M. Wright. London, England: Archetype Publications Ltd. 112-117.

Neich, R., and M. Pendergrast. 1997. *Traditional tapa textiles of the Pacific.* London, England: Thames & Hudson.

Norton, R. 2012. Personal communication. Field Museum of Natural History, Chicago, IL.

Pritchard, M. J. 1984. *Siapo: Bark cloth art of Samoa.* American Samoa: Council on Culture, Arts and Humanities Special Publication No. 1.

Rose, R. G., C. Turchan, N. Firnhaber, and L. O. Brown. 1988. The Bishop Museum Tapa Collection: Conservation and research into special problems. *Bishop Museum Occasional Papers* 28: 1-34.

Wharton, W. J. L., ed. 1893. *Captain Cook's journal during his first voyage round the world made in H.M. Bark "Endeavor" in 1768-71.* London, England: Elliot Stock.

Wright, M. M., ed. 2001. *Barkcloth: Aspects of preparation, use, deterioration, conservation and Display.* London, England: Archetype Publications Ltd.

FURTHER READING

Barker, J. 2008. *Ancestral lines: The Maisin of Papua New Guinea and the fate of the rainforest*. Toronto, Canada: Higher Education University of Toronto Press Inc.

Bell, L. A. 1983. *Papyrus, tapa, amate & rice paper: Papermaking in Africa, the Pacific, Latin America & Southeast Asia.* McMinnville, OR: Liliaceae Press.

Cusenier, P. 1998. *Tapa: Bark cloth of Oceania.* Paris, France: Galerie Meyer.

Daniels, V. 2001. Research into the deterioration of barkcloth. In *Barkcloth: Aspects of preparation, use, deterioration, conservation and display*, ed. M. M. Wright. London, England: Archetype Publications Ltd. 20-23.

Florian, M. E., D. P. Kronkright, and R. E. Norton. 1990. *The conservation of artifacts made from plant materials.* Marina del Ray, CA: Getty Conservation Institute.

Freitas, C. 1980. Tapa in ancient Hawaii. Paper presented at the Tapa, Washi and Western Handmade Paper Symposium, Honolulu Academy of Arts, Honolulu, Hawaii.

James, K. E. 1988. *Making mats and barkcloth in the kingdom of Tonga*. LOCATION: Australia: K. E. James.

Johnson, E. 2001. The deacidification and conservation of a Samoan tapa at the Manchester Museum. In *Barkcloth: Aspects of preparation, use, deterioration, conservation and display,* ed. M. M. Wright. London, England: Archetype Publications Ltd. 71-95.

Kamakau, S. M. 1976. *The works of the people of old*. Translated by Mary Kawena Pukui. Honolulu, HI: Bishop Museum Press.

Martin, J. 1981. *Tongan islands: William Mariner's account.* Naku'alofa, Tonga, South Pacific: Vava'u Press.

Pole, L. 2001. African barkcloth, with particular reference to Ghana. In *Barkcloth: Aspects of preparation, use, deterioration, conservation and display,* ed. M. M. Wright. London, England: Archetype Publications Ltd. 1-9.

Pule, J., and N. Thomas. 2005. *Hiapo: Past and present in Niuean barkcloth.* Dunedin, New Zealand: University of Otago Press.

Tamahori, M. J. 1963. *Cultural change in Tongan bark-cloth manufacture*. Master's thesis, University of Auckland, New Zealand.

Tolstoy, P. 1991. Paper route. *Natural History* 6: 6-8, 10, 12-14.

Von Hagen, V. W. 1999. *The Aztec and Maya papermakers*. Mineola, NY: Dover Publications Inc.

Westervelt, W. D. 1939. *Hawaiian legends of Old Honolulu.* Rutland, VT: Charles E. Tuttle Co.

JILL M. IACCHEI
Senior Conservation Technician
Cornell University
Ithaca, NY
ji49@cornell.edu

Exploring New Glass Technology for the Glazing of Papyri

INTRODUCTION

There is a general consensus that papyrus is best handled, exhibited, and stored between sheets of a transparent rigid material such as glass; however, debates remain as to the very best material for glazing. Managers and conservators of papyrus collections strive to use a material that is strong, light-weight, and withstands moderate handling and travel. Historically, soda-lime glass has been used, with acrylic being more recently favored in some institutions. The use of damaging materials such as cellulose nitrate, cellulose acetate, and static-laden polyester films are also found in collections (Leach and Tait 2000, 245). There has been much advancement in the field of glass manufacture in recent years, influenced by the need for a light-weight, scratch-resistant, and unbreakable glass for the manufacture of watches, cell phones, personal computers, and tablets. Brands of high-quality alkali-aluminosilicate glass such as Corning Gorilla Glass, Asahi Dragontrail, and Schott Xensation, are a key part of the electronic devices we use every day. The application of glass proven to be extraordinarily stable is worth exploring for use in glazing papyri. These new glass products are created using a high ion exchange (HIE) fusion process, which produces glass with extremely high impact and bending strength, as well as scratch and crack resistance, while keeping the sheets thinner, lighter, and clearer than traditional panes of glass.[1] With a particular focus on Gorilla Glass, this article will explore how new types of glass may be successfully employed in the housing of papyri, including economic feasibility and an investigation of how it handles under stress in a variety of environments.

At the University of Michigan (U-M), with a collection of well over 18,000 fragments, one has to be very economical about how papyri are housed. It is not possible to glaze every fragment. There is not enough space, time, or resources to accomplish such an overwhelming task. Generally, papyrologists will separate fragments of interest from the hundreds within boxes for conservation treatment. Each of these fragments is a potential treasure, but housing them after treatment and cataloging is a challenge. A solution at U-M is to house fragments in folders within clamshell boxes in a temperature and humidity-controlled vault (fig. 1), in which case 100% cotton blotter paper that has a slight texture to the surface is adhered to 20-point folder stock and the fragment is placed within (fig. 2). The texture keeps the papyrus from sliding within the folder. If there are multiple fragments associated with an inventory number, each fragment is placed in its own acid-free tissue folder, which is held within the larger folder (fig. 3). Glazing is designated for items that are handled frequently for scholarship and tours, displayed in exhibits, or going on loan. In general, U-M fragments have been glazed with annealed soda-lime glass, also referred to as float or window glass. The edges are lightly sanded, and the glass distributor provides sheets that contain no bubbles, flaws, or scratches. The edges of the glass sandwich are sealed with Filmoplast SH, which is a white linen tape (fig. 4). When fragments are glazed at U-M, the papyrus is anchored to the glass using tiny strips of glassine, which is precoated with dextrin adhesive and can be remoistened with water, but this material is now difficult to acquire (fig. 5). More frequently, people use light-weight Japanese paper and wheat starch paste for anchoring papyrus to the glass. Most glazed items are stored vertically in the vault so that there is no weight resting on the fragments (fig. 6). For larger pieces that need to be stored horizontally, no more than a few are stacked. The largest challenge is housing oversized pieces. The majority of U-M's oversized papyri are currently glazed with acrylic. Some pieces are in special aluminum frames to keep them from torqueing, but the acrylic still presents problems to be discussed further, especially at this large size (fig. 7) (Kaye 2015).

HISTORIC OVERVIEW

There is a multitude of different materials historically used for glazing papyri. Many pieces collected in the 19th century, especially those in the British Museum collections, were mounted onto paper or board with a sheet of glass placed on top and bound along the edges with strips of leather or tape. Papyri were sometimes lined with linen as well. When fragments had writing on both sides, they were sandwiched between two sheets of glass. Regular window glass is still the most widely acceptable material for mounting papyri.

Fig. 1. Clamshell boxes housing papyri on shelves in the environmentally controlled vault at U-M.

Fig. 3. Multiple fragments between tissue in one folder.

Nitrocellulose film was used occasionally to back fragments. These fragments completely blackened and disintegrated, and there is nothing that can be done to save them. They were essentially "cooked" by the off-gassing chemicals, the way we see old movie film disintegrating at rapid rates. Fragments that were backed with gelatin film have deteriorated but remain comparatively stable. Wood and paper-based board backings are prone to warp and distort, damaging the papyrus. The only board that may be safe to use as a backing is Tycore honeycomb board, but this obviously cannot be used with pieces that are double sided. Laminated glass, such as safety glass, is much too heavy to be realistic. When regular glass breaks, it is held in place by the binding tape along the edges, so although laminated glass seems less prone to breaking, it is overkill. Last, Mylar (also known as Melinex or polyester film) is much too flexible and holds a tremendous amount of static—a problem that will also be explored further in this article.

There are about a half-dozen articles specifically written about 20th and 21st century papyrus housing methods, such as that at the Brooklyn Museum, Yale, and Princeton, which all use acrylic sheeting (Owen and Danzing 1993; Noack 1986; Stanley 1994). In Princeton's case, the housing also uses Stabiltex, which is a polyester multifilament textile, and Mylar. Papyrus fragments were stored in a different plastic material called *Vinylite* at the University of California, Berkeley (UCB) several decades ago. UCB provided some images of the damage done from their collections being housed in Vinylite, which is similar to Mylar (fig. 8). Vinylite is thin and flexible, and studies show that it is full of static. The intentions were excellent at UCB: since they are located right over an active earthquake fault, they did not want to use glass. Fragments were housed in Vinylite with the greatest care decades ago. But the static and flexibility of the material broke down the papyrus, turning it to dust. In the 1990s, UCB conservators worked with scientists in the university's microelectronics facility to find a system that would allow for safely opening the Vinylite enclosures. They ultimately worked with a company called *Ion Systems*, which supplied the air ionization system installed at the microelectronics facility at UCB. After careful measurements, static was proven to be the main cause of the harm done to the papyri in Vinylite (Steinman 1997). They ended

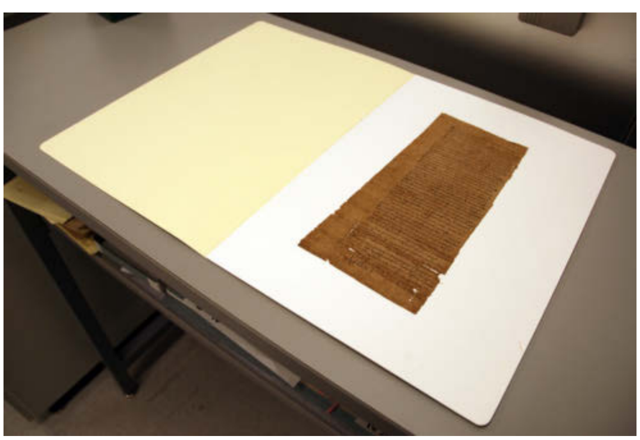


Fig. 2. Papyrus fragment in a folder.

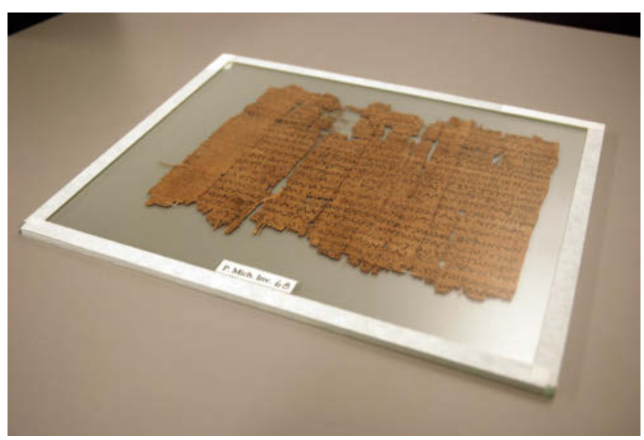


Fig. 4. Papyrus fragment glazed with annealed soda-lime glass.

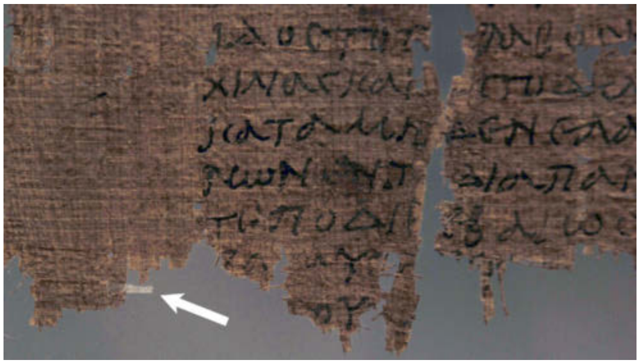


Fig. 5. Glassine anchor holding papyrus in glazing.

up using an air ionizer when opening the Vinylite housings to mitigate further damage (fig. 9). This worked well for them, and it is now an important piece of equipment to have on hand when working with plastic housing materials in a papyrus collection. The ionizer is mounted about 30 to 40 cm away from the item, operated at a low fan speed, and both sides of the package are then neutralized as it sits on the work surface.

Fig. 6. Vertical storage of glazed papyri at U-M.

Fig. 7. Oversized papyrus in an aluminum frame.

THE USE OF ACRYLIC

Due to its popularity, acrylic must be addressed further. It is a highly desirable and frequently discussed material that many people turn to for the housing of papyrus. There are many different grades and types of acrylic, but the most reputable company in the United States is Tru Vue, which makes glazing products that are used by conservators and museum professionals and has conducted a lot of testing and scientific research to support the validity of their products (please refer to Tru Vue's company website for in-depth studies and options). One of their specialties is Optium Museum Acrylic, which is a conservation-grade glazing that incorporates a UV-blocking layer, along with an optical coating that allows for excellent light transmission and no reflection. It is also manufactured to be antistatic. In the past, acrylic often yellowed and discolored over time, and the thickness did not allow for the best visibility. Tru Vue prides itself in lessening the reflection that bounces off the surface, as well as creating a surface that is no longer easily scratched. The regular Optium Acrylic nonmuseum

Fig. 8. UCB, old housing using Vinylite. Courtesy of the Center for the Tebtunis Papyri, The Bancroft Library, University of California, Berkeley.

Fig. 9. Air ionizer used to reduce static when opening plastic housings.

variety does not protect against UV, but papyrus collections are rarely exposed to UV light for long periods of time and exhibit cases are often built with UV filtering capabilities. In the search for a potentially safe acrylic for papyrus, Tru Vue's StaticShield looks the most desirable and one that is chosen by colleagues working with papyrus collections. It is hard to find anything wrong with this product, as it claims to be more antistatic than glass, is scratch resistant and shatter resistant, and cleans like glass. But what raises concern is the proprietary coating engineered for static control. Whenever there is a coating that cannot be readily identified, one must consider whether its components can leach out over time, especially since it will be in direct contact with the papyrus. Tru Vue's glazing was not designed with direct contact in mind—in general, when artwork is framed, there is a window mat or spacers between the artwork and the glazing. This is a consideration when thinking of materials to use for glazing papyri, which will be touching the glazing material directly.

If acrylic remains the material of choice, at least the data shows that the antistatic properties of StaticShield hold up for long-lasting protection, and it also proves to be abrasion resistant, another strong plus. But no matter how many great properties a piece of acrylic may display, a major downside is its flexibility. This property may make it less prone to breaking, but when it comes to the papyri being supported between sheets of acrylic, the flexing can cause real damage. The oversized items at U-M that are housed in unframed acrylic readily flex, resulting in risk whenever handled (fig. 10). Even when handled with care, grabbing the piece from one end will inevitably flex the entire package, potentially causing breaks or at the very least putting undue stress on the papyrus that is anchored on the acrylic. Additionally, some oversized items at U-M are mounted on foam board lined with fabric, with a sheet of acrylic resting on top of the papyrus. The

Fig. 10. Flexing of acrylic glazing.

static from the acrylic has caused small fibers to break off and scatter, some of which likely contain ink (fig. 11). Although pricier and newer varieties of acrylic may have improved working abilities, the higher-quality choices are not always what people purchase outside the conservation community, due to budget constraints or lack of knowledge about all of the choices available on the market. Concerns over coatings and the expansion and contraction of acrylic with fluctuations in humidity and temperature must still be considered. The papyrus at U-M is kept in a temperature-controlled storage vault, but the room where people use the collections has variable conditions and at times the temperature has risen to 26°C at a higher humidity than is appropriate for papyrus, so stability of the glazing material is a big concern. Acrylic sheets

Fig. 11. Small fibers scattered due to static from acrylic glazing.

have an expansion allowance of 1.6 to 6.0 mm depending on temperature and humidity (True Vue 2017). In addition, acrylic is more expensive than glass. Not many people are aware that acrylic is petroleum based, so it is susceptible to oil price spikes. As with gasoline, when the cost of a barrel of oil goes up, so does the price of acrylic.

THE USE OF SODA-LIME GLASS

Aside from the popularity of acrylic, attention must turn back to soda-lime glass, because it is still used in the majority of papyrus collections today. The glass starts out as a mixture of very fine powders, including limestone, silica sand, and soda ash. The raw materials are very inexpensive, keeping it the most cost-effective option. Annealed soda-lime glass is used at U-M. When glass is annealed, it is slowly cooled to relieve internal stresses. When not annealed, glass is more likely to crack when exposed to temperature changes. Annealed glass will break off into large, sharp shards, which obviously poses safety risks. Another soda-lime glass variety to consider is chemically strengthened. As described by a representative at the glass distributor Abrisa Technologies, annealed glass is not the same as chemically strengthened. Most float glass is considered annealed glass. Chemical strengthening of glass requires that the glass be placed into a chemical bath for a prescribed amount of time, and the compression of the top layers of the glass is thus changed, making it stronger and more scratch resistant. Another popular glass variety used in the conservation community is borosilicate glass. This glass is commonly known for its use in laboratory glassware as well as Pyrex products. Glass chemist Otto Schott developed this glass to withstand sudden, uneven temperature shifts without shattering. This quality was obtained when Schott included boron in the glass recipe, which was later perfected by Corning scientists. Boron moderates vibrations that can cause shattering by making the distance between atoms in the glass almost identical, resulting in nearly zero net movement of the glass atoms (Corning Museum of Glass 2011). With so little expansion, the glass does not break. Most notably, it is used to replace deteriorated glass in the conservation of daguerreotypes because it is physically stable, chemically inert, and highly transparent, and has been tested in the conservation field as a component of accelerated aging packages for decades (Bulat et al. 2009, 151). It is proven to be at least twice as stable as regular soda-lime glass and can be ordered in varying thicknesses. A downside is that unlike soda-lime glass, it cannot be cut by hand and the cost is more significant.

With so many choices, debate over the best choice remains. Several years ago, on a discussion list for papyrologists, experts argued over the use of glass versus Perspex (acrylic) (Bulow-Jacobsen 2014). Some of the most respected papyrus conservators in the world, including Bridget Leach, Myriam Krutzsch, and Leyla Lau-Lamb, responded with their complete support for the use of glass. In her response and numerous publications, Leach emphasizes that glass is preferred precisely because it requires such great care to handle. She explains that in her observations at the British Museum, glass has cracked or broken but the papyrus remained relatively unharmed because the glass takes the impact of the vibration and damage involved, not the papyrus (Leach 2005, 195). To date, papyrus conservators have not published accounts on trouble with ink offsetting from papyrus onto glass. It is a very inert, smooth surface with no risk of abrasion or static. Glass is very easy to clean with plain water and a paper towel, so no chemicals or special solutions are required. It may be breakable, but history shows that even when it cracks, the harm to the papyrus remains minimal because the damage is contained by the support of the second sheet and the binding at the edges. These items should be handled with the greatest care in the first place, so handling glass carefully is not an unreasonable request. The main disadvantage is the microenvironment that is created between the two sheets, which can be seen manifesting in salt blooms. Papyrus contains salt deposits from being buried and exposed to soil at archaeological sites. The source of salt in the soil largely stems from the limestone and clays that lie beneath the desert sand. The composition of the salt is the same as simple table salt, and extensive research has shown that it does not harm the papyrus. If the bloom greatly disrupts legibility, it can simply be cleaned away from the glass with water or a little ethanol and water mixture, and the piece can be reglazed again. Removing salt efflorescence must be considered carefully, however, because the salt may be an inherent part of the history of the papyrus, potentially revealing clues as to its origin and use (Neate, Decoux, and Pollard 2011, 153).

NEW GLASS TECHNOLOGY

Along with the many pros and cons to consider with the more traditional glazing materials, it is time to consider new glass technology. Corning has always been a leader in glass manufacturing in the United States, and when cell phones and tablets took over the world, they observed that regular glass was not succeeding as a screen material. A tougher and more light-weight glass was required for portable electronics, so using glass technology that they developed in the 1960s as inspiration, in 2006 Corning scientists started developing a glass that was damage resistant with a pristine surface quality and free of environmentally harmful materials such as arsenic, lead, and antimony. Corning uses a fusion-draw process that enables them to make the glass extremely thin, so grinding and polishing is not required, which are steps that can introduce flaws that weaken the glass matrix. The alkali-aluminosilicate sheet glass that they developed, which they named *Gorilla Glass*, is ideal for the touch technology used in sleek electronic devices. There is a deep layer of high compressive stress created through an ion-exchange process, which is a type of chemical strengthening or tempering. Large ions are stuffed into the glass surface, creating a state of compression. The compression acts as a sort of "armor," making the glass extremely tough and damage resistant. There have been five generations of Gorilla Glass to date, with each generation becoming thinner. It can be produced at a thinness of 0.4 mm. Gorilla Glass is by no means damage proof if subjected to enough abuse, but it is better at surviving real-world events. The larger chemically strengthened depth in the Gorilla Glass prevents the damage from extending far into the matrix when compared to soda-lime glass. Illustrations provided by Corning in their product information sheets demonstrate the way damage is suppressed in Gorilla Glass (Corning Gorilla Glass 2017). For example, the comparison of a scratch test applied to the two kinds of glass clearly demonstrates how scratches are visible to the naked eye in soda-lime glass but nearly invisible in Gorilla Glass. Corning also created a Gorilla Glass variety that is antimicrobial, but one must remain wary of the coating they use. The coating is not meant to last longer than the lifespan of a typical device, which is really not long at all, considering that people cycle through their devices every few years. Corning developed an easy-to-clean coating as well, but again, it is not clear how stable it is or what goes into it that may potentially harm a papyrus fragment in direct contact with the surface. Another consideration is that haze is a problem with soda-lime glass as it ages, and regular noncoated Gorilla Glass is not immune to haze but still outperforms soda-lime glass.[2]

A small collection of samples from a few glass distributors was obtained for experimentation, including samples obtained directly from Corning, the manufacturer. Corning's business director of emerging innovations, Hank Dunnenberger, provided samples of Gorilla Glass-1 in various thicknesses including some oversized pieces. Although the clarity and lightness of the largest pieces are unparalleled, they were very flexible. The large pieces used for experimentation were 1 mm in thickness, which was the thickest available for the largest sheets. Figure 12 illustrates two 1-mm pieces placed together, which still remain flexible. It is strong, but the flexibility is a problem with papyrus unless the piece is single sided and mounted on a stiff board such as Hexamount, which is the most dimensionally stable of any fiber-based mounting board. Another solution is to build trays out of Tycore and then place the papyrus glazed in Gorilla Glass in the tray for handling. But it remains a challenge if a papyrus has writing on both sides and would require careful support to turn it over. Acrylic has the same flexibility problem, so the downside is shared between the two materials. A frame is another potential solution for increasing stability, such as the aluminum frames used at U-M for the oversized pieces glazed with acrylic. Apart from flexibility, another downside to Gorilla Glass is that Corning is unable to provide any information or test results on the longevity of aluminosilicate glass, as there are no artificial aging tests completed to date. Personal consultation with glass scientists shows confidence that the aging will directly parallel other trusted varieties of glass due to the fact that it contains no harmful ingredients; however, this has not been technically proven when it comes to aluminosilicate glass. There is a lack of urgency to prove longevity, likely due to the short life spans of electronic devices where it is used most. Despite some of the unknowns, the conservation department at the University of Chicago Library recently put Gorilla Glass to use for one of their papyrus fragments. The Gorilla Glass they ordered was .11 cm thick and from McMaster-Carr.[3] Personal communication with Ann Lindsey, head of conservation, shows a high level of satisfaction with the material. Although there was some worry about the thin glass torquing, it did not show any movement with two layers taped together. Patti Gibbons, head of collections management in special collections at the University of Chicago, stated: "So far, I, too, think the papyrus glass is a nice solution. It looks wonderful, it is lightweight, and easy to handle. The older glass is much thicker and gives me 'crash anxiety' where I worry about handling accidents where someone would accidentally drop and shatter the glass and harm the papyrus fragment."

Fig. 12. Flexing two pieces of 1-mm-thick Gorilla Glass sandwiched together.

CONCLUSION

Pros and cons run through all three materials, as seen in figure 13. The workability of Gorilla Glass with papyrus proved to be satisfying overall; however, for the time being, soda-lime glass will be kept in use at U-M due largely to budgetary restrictions. It is worth pursuing the use of Gorilla Glass for special cases, groups of items that are handled frequently, and larger items, despite the flexibility of large pieces. The ease of handling, stability in different climates, easy cleaning, and light weight in storage would make Gorilla Glass a joy in a papyrus collection. The fact that there is little to no concern over scratches and the optical clarity is extremely sharp is also appealing when thinking of users' needs. But if Gorilla Glass is too expensive, at least

Gorilla Glass	Soda-lime Glass	Acrylic
Nearly unbreakable	Can break & damage papyrus	Shatter-proof
Easy care & scratch-resistant	Easy care & scratch-resistant	Requires special cleaner & soft cloth; easily scratched
Lightweight, thin, flexible	Heavy, thin, inflexible	Lightweight, thick, flexible
Optically clear with no discoloration over time	Green tint; color distortion with extra thickness or coatings	Clear but can yellow over time
Nonporous & impermeable	Nonporous & impermeable	Permeable to gas, including water vapor
Most expensive	Cheap	Expensive
Easy transport	Difficult transport	Easy transport
Non-flammable	Non-flammable	Flammable
No size fluctuations	Negligible size fluctuations	Expands & contracts due to temp & humidity

Fig. 13. Pros and cons of soda-lime glass, acrylic, and Gorilla Glass.

conservators and papyrologists can be confident about the dimensional stability and impermeability of glass in general, still making it a safe choice for years to come. In the end, the reality of Gorilla Glass comes down to cost. A cost comparison for each type of glass can be found in figure 14. The high cost of several of these options is likely to be prohibitive in many institutions. Perhaps if grant money is obtained for a housing project, the choices can broaden. Anyone can appreciate the rarity and awe-inspiring survival of papyrus, and proposing to use a material for its housing that can withstand the stresses of use even better than any material encountered to date does not seem too much to ask. The industries that are beginning to request Gorilla Glass are expanding rapidly, most notably in the automotive industry (Ulanoff 2017). As it starts to be used for more products in the world, the cost of Gorilla Glass is also likely to decrease, making it the material of choice for glazing papyri, bringing the ancient and modern to a unique crossroads.

Type	Size	Cost
Annealed (heat strengthened) soda-lime glass	8 x10", 1.1 mm	$8.61
Chemically strengthened soda-lime glass	8x10", 1.1 mm	$9.97
Tru Vue StaticShield acrylic	8 x10", 3 mm (thinnest available)	$14
Borosilicate glass	8 x 10", 1.1 mm	$20.40
Gorilla Glass	8 x 10", 1.6 mm	$25.55

Fig. 14. Cost comparison of available glazing materials.

ACKNOWLEDGMENTS

The author would like to thank the following for their support, connections, samples, and expertise: Shannon Zachary, head of Preservation and Conservation, U-M; Leyla Lau-Lamb, conservator of Books and Papyrus (retired), U-M; Brendan Haug, archivist for the Papyrology Collection and assistant professor of the Department of Classical Studies, U-M; Monica Tsuneishi, manager of the Papyrology Collection, U-M; John Allison, professor, Materials Science and Engineering, U-M; John Halloran, professor, Materials Science and Engineering, U-M; Hank Dunnenberger, business director of the Emerging Innovations Group, Science and Technology, Corning Inc.; Stemmerich Inc., glass distributor; and Abrisa Technologies, Industrial Glass Division, glass distributor.

NOTES

1. Technical details and videos on Corning fusion manufacturing process: https://www.corning.com/gorillaglass/worldwide/en/technology/how-it-s-made.html.
2. Please refer to Corning's company website for more information on Gorilla Glass: https://www.corning.com/gorillaglass/worldwide/en/technology/technology-overview.html.
3. McMaster-Carr Gorilla Glass size and price list: https://www.mcmaster.com/#gorilla-glass/=16wbnuq.

REFERENCES

Bulat, E., I. Spartz, B. Bernier, and T. R. Holdcraft. 2009. A case for preservation: Revisiting the Agassiz Collection of daguerreotypes from the Peabody Museum Archives at Harvard University. *Topics in Photographic Preservation* 13: 147-159. http://resources.conservation-us.org/pmgtopics/2009-volume-thirteen/1_21_Bulat.pdf.

Bulow-Jacobsen, A. (9 July 2014). PAPY mailing list. http://lists.hum.ku.dk/pipermail/papy/2014-July/001598.html

Corning Museum of Glass. 2011. All about glass. https://www.cmog.org/article/finding-right-recipe-borosilicate-glass.

Corning Gorilla Glass. 2017. Gorilla Glass 2 product information sheet. http://www.valleydesign.com/Datasheets/Corning%20Gorilla%20Glass.pdf.

Kaye, M. 2015. Housing papyrus at the University of Michigan Library. *Archival Products Newsletter* 19 (1): 1-3. http://www.archival.com/newsletters/apnewsvol19no1.pdf.

Leach, B. 2005. Mounting papyri at the British Museum. In *Art on paper: Mounting and housing*, eds. J. Rayner, J. M. Kosek, and B. Christensen. London, England: Archetype Publications. 193-198.

Leach, B., and J. Tait. 2000. Papyrus. In *Ancient Egyptian materials and technology*, eds. P. T. Nicholson and I. Shaw. Cambridge, England: Cambridge University Press. 227-253.

Neate, S., S. Decoux, and M. Pollard. 2011. An investigation of the extent and causes of salt migration in the papyrus and related collections in the Bodleian Library. *Restaurator* 32 (2): 135-159. https://www.degruyter.com/view/j/rest.2011.32.issue-2/rest.2011.008/rest.2011.008.xml.

Noack, G. 1986. Conservation of Yale's papyrus collection. *AIC Book and Paper Group Annual* 4: 61-73.

Owen, A., and R. Danzing. 1993. The history and treatment of the papyrus collection at the Brooklyn Museum. *AIC Book and Paper Group Annual* 12: 36-40. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v12/bp12-10.html.

Stanley, T. 1994. Papyrus storage at Princeton University. *AIC Book and Paper Group Annual* 13: 49-55. http://cool.conservation-us.org/coolaic/sg/bpg/annual/v13/bp13-10.html.

Steinman, A. 1997. Static control technology preserves ancient Egyptian artifacts. *Proceedings of the Electrical Overstress/Electrostatic Discharge Symposium*. Santa Clara, CA. 1-12.

True Vue. 2017. Acrylic collection facts and specifications. http://tru-vue.com/2016/01/acrylic-collection-facts-and-specifications/.

Ulanoff, L. 2017. Gorilla Glass is not just for iPhones anymore. *Mashable* (January 15). http://mashable.com/2017/01/05/corning-gorilla-automotive-glass-ces/#L6JZhtwSnOqZ.

FURTHER READING

Ball, P. 2015. Concrete mixing for gorillas. *Nature Materials* 14 (May): 472. http://www.nature.com/nmat/journal/v14/n5/full/nmat4279.html.

Bark, J. 2015. Acrylic glazing: Towards invisible protection. *Picture Framing Magazine* (May): 24-28. http://www.barkframeworks.com/articles/acrylic-glazing-towards-invisible-protection.

DeCoux, J. 2015. Understanding anti-static acrylic. *Tru Vue*. http://tru-vue.com/wp-content/uploads/2015/11/14_tru_377_anti_static_article_v4.pdf.

Dormehl, L. 2014. How Corning won Apple back and built the strongest Gorilla Glass yet. *Cult of Mac* (November 26). http://www.cultofmac.com/304120/corning-gorilla-glass-4/.

Gardiner, B. 2012. Glass works: How Corning created the ultrathin, ultrastrong material of the future. *Wired Magazine* (September 24). https://www.wired.com/2012/09/ff-corning-gorilla-glass/.

Ginter, S. 2010. Gorilla Glass protects the Samsung Galaxy Tab from breaking. *Talk Android* (October 5). http://www.talkandroid.com/16374-gorilla-glass-protects-the-samsung-galaxy-tab-from-breakage/#&gid=1&pid=16377.

Gomez, S., M. J. Dejneka, A. J. Ellison, and K. R. Rossington. 2011. A look at the chemical strengthening process: Alkali aluminosilicate glasses vs. soda-lime glass. In *71st conference on glass problems: Ceramic engineering and science proceedings, Volume 32*. Westerville, OH: American Ceramic Society. 61-66. http://onlinelibrary.wiley.com/doi/10.1002/9781118095348.ch6/summary.

Grad, P. 2016. Innovation and demand keeps glass industry afloat. *Chemical Engineering* 6 (14): 16-18. http://www.chemengonline.com/innovation-demand-keeps-glass-industry-afloat/?printmode=1.

Mauro, J. C., C. S. Philip, D. J. Vaughn, and M. S. Pambianchi. 2014. Glass science in the United States: Current status and future directions. *International Journal of Applied Glass Science* 5 (1): 2-15. http://onlinelibrary.wiley.com/doi/10.1111/ijag.12058/full.

Miller, J. A. 2011. Out of a near-death experience into a chaotic global economy: How Corning rediscovered its innovation roots. *Research-Technology Management* 54(6):26-31. http://www.tandfonline.com/doi/pdf/10.5437/08956308X5406012.

O'Grady, J. D. 2012. The fascinating science of Gorilla Glass. *Apple Core* (October 12). http://www.zdnet.com/article/the-fascinating-science-of-gorilla-glass/.

Phibbs, H. 2014. Glass or acrylic? Considerations for framed artwork. *Tru Vue*. http://tru-vue.com/2014/10/glass-or-acrylic-considerations-for-framed-artwork/.

Sabia, R., and N. Shashidhar. 2010. Easy-to-clean surfaces for mobile devices. *Corning Gorilla Glass White Paper* (November): 1-4. http://www.corning.com/microsites/csm/gorillaglass/PI_Sheets/WP_Easy_to_Clean_Surfaces.pdf.

Walton, D. 2010. Specialty glass: A new design element in consumer electronics. *Electronic Design*. http://electronicdesign.com/mobile/specialty-glass-new-design-element-consumer-electronics.

MARIEKA KAYE
Harry A. and Margaret D. Towsley Foundation
Conservation Librarian
Book and Paper Conservator
University of Michigan Library
Ann Arbor, MI
marieka@umich.edu