Objects Specialty Group Postprints Volume Sixteen, 2009

Proceedings of the Objects Specialty Group Session
May 20 and 22, 2009

AMERICAN INSTITUTE FOR CONSERVATION OF HISTORIC AND ARTISTIC WORKS

37th Annual Meeting
Los Angeles, California

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OBJECTS

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Objects Specialty Group Postprints
Volume Sixteen, 2009

Compiled by Helen Alten, Program Chair
with Christine Del Re, Patricia Griffin, Emily Hamilton, Kari Kipper, and Carolyn Riccardelli

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This publication entitled *Objects Specialty Group Postprints, Volume Sixteen, 2009* is produced by the Objects Specialty Group of the American Institute for Conservation of Historic & Artistic Works.

Cover photograph by Giovanna Fregni.

The papers presented in this publication have been edited for clarity and content but have not undergone a formal process of peer review. This publication is primarily intended for the members of the Objects Specialty Group of the American Institute for Conservation of Historic & Artistic Works. Additional copies of this publication are available for purchase by contacting AIC.

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Program Chair's Foreword

The theme for the 37th Annual Meeting of the American Institute for Conservation was **Conservation 2.0—New Directions**. I interpreted this inspiring topic to mean a call for new ideas and innovative treatment approaches, a way to share the frontiers and ground-breaking research of our craft. I was looking for specific details on how treatments were accomplished using new techniques or innovative approaches to old techniques and materials. In some cases, the conservation treatment was relatively well-known, such as laser cleaning, but the material isn't as well represented in our literature, such as lipstick and aluminum and feathers.

We also tried to incorporate some changes and innovative new approaches to how the objects session was organized. For the first time we had a luncheon with a tips session, similar to the popular luncheon annually provided by the Paintings Specialty Group. Also, another first, we split our papers over two days, sharing one day with the Wooden Artifacts Specialty Group, so there was less overlap between the two sets of papers. The chosen papers naturally separated into four categories: Modern Polymers, Ethnographic Materials, Archaeological Metals, and Fine Arts Metals.

On Wednesday, May 20, 2009, we began the meeting with a two-hour luncheon and tips session. The tips were short, 15-minute presentations with a lot of time for questions and discussion. A useful online tool for communicating with clients was presented Candis Griggs Hakim and her husband Mather Hakim. He had developed The Faculte "Broadcast," a web-based multimedia communication platform available at minimal cost (currently free) that easily creates a mini "movie" for an online treatment proposal a client can view. In the second tip, Gretchen Anderson showed how her museum had retrofitted Delta Design cabinet drawers so that they sealed tight with a Plexiglas lid for low relative humidity metals storage. Finally, Nancy Fonicello shared her tips for cleaning feather bonnets, which led to a lively discussion about feather cleaning and handling. Of these three tips, only one, Gretchen's cabinet retrofits, is in this postprint. Nancy and Candis' presentations were blogged by Ellen Carrlee.

Our session started with Modern Polymers. L. H. (Hugh) Shockey, Jr. showed another example of a carbon dioxide snow cleaning technique, this time showing the specifics of how it was done and how it could be used to take the bloom off a deteriorating polymer sculpture. He showed a video of the process, which clearly illustrated the noise as well as the speed of the technique. Anna Comiotto introduced a new tool, the plasma pen, for improving polymer adhesion. The session concluded with Elizabeth Homberger and Carl Patterson's presentation on lipstick-coated objects that were sweating and gathering dust. All three of these papers are provided in this postprints volume.

After a break, Cap Sease chaired the session on Ethnographic Materials. This session was dedicated to Ginny Greene and her life-long support of the Objects Specialty Group and conservation. Ginny, retired conservator of the University of Pennsylvania Museum of Archaeology and Anthropology, trained many pre-program and program objects interns. Ginny also served as the OSG Publications Chair for many years, selflessly compiling printed volumes of each year's talks. A special publication of papers by her former interns and students was compiled as a retirement gift for Ginny. Meg Loew Craft's presentation, "Examination of an

Egyptian Corn Mummy," which launched our ethnographic session, appears in Ginny's memorial publication, and is not included here. She discussed the mummy's history, construction and analytical results, including a CT scan. Nancy Fonicello and her colleagues continued the ethnographic session with a summary of analytical work on painted hide robes at the Ethnological Museum in Berlin. Dyes and pesticides were identified using HPLC and FTIR. Quillwork dyes were compared with known local dye plants prepared by Nancy. The ethnographic session concluded with "It Takes Guts," presented by Kelly McHugh, Kim Cullen Cobb, Michele Austin-Dennehy, and Landis Smith, giving an excellent history of gut and its cultural uses. The paper also explores the philosophy of repair, and emphasizes Native stewardship and values, something conservators sometimes neglect to consider. The latter two talks are published here.

We returned on Friday, May 22, 2009, for the Archaeological Interest Group Breakfast followed by three talks. Howard Wellman introduced the Archaeological Metals speakers. Alice Peterakis launched the session with an update of conservation work at Kaman-Kalehöyük, focusing on a student metals storage project that nicely complemented Gretchen Anderson's presentation two days earlier. Gretchen Anderson returned with Giovanni Fregni to give an overview of digital imaging techniques and how they might be used to benefit conservation activities and reduce object handling of fragile archaeological metals. The session concluded with "Connecting Materials Science and Engineering with Archaeological Conservation" presented by Paul Mardikian. The iron ship *H. L. Hunley*, excavated from a marine environment, has been used in research to improve and speed-up iron desalination. This paper is not presented in this volume. Again, look to Ellen Carrlee's blog of this session for more information.

The morning ended with some fascinating papers on metals. None of those papers have been submitted for publication, nor were they blogged, which is unfortunate. Michael Barrett, Mark Lewis, and Scott Nolley's "The Laser Cleaning of Anna Hyatt Huntington's Aluminum Sculpture *The Torch Bearers*" showed how a much publicized cleaning technique could be used on a less well-publicized material, aluminum. Curtis Desselles, Mary F. Striegel, and Jason Church showed how eddy currents could help clarify inscriptions and makers' marks in "Innovations in Eddy Current Analysis of Metals for Heritage Preservation." The talks concluded with John Scott's presentation, "Biotechnology for Objects Conservation," discussing some of the formulations he has been using on outdoor sculptures.

As Program Chair, I am grateful to the guidance of my predecessor, Howard Wellman, as well as the rest of the OSG committee chairs, other specialty group program chairs, and AIC staff, all of whom helped to ensure this was a stellar program. In particular, Susanne Grieve and Vanessa Muros chaired the Archaeological Interest Group breakfast, and Cap Sease and Chris Del Re took the lead on the ethnographic session honoring Ginny Greene. Special thanks to all who submitted papers. Finally, special thanks to Ellen Carrlee, who documented many presentations in her well-written blog. To see her comments on the papers that were not submitted for publication in the OSG Postprints, go to http://ellencarrlee.wordpress.com/2009/05/.

Helen Alten, OSG Program Chair 2009

MICROCLIMATE STORAGE FOR METALS (AND OTHER HUMIDITY-SENSITIVE COLLECTIONS): PRACTICAL SOLUTIONS

GRETCHEN ANDERSON

ABSTRACT

We all know that environmental conditions for collections, either in storage or exhibition, are rarely ideal. And sometimes they are dreadful. This is particularly true for humidity-sensitive collections such as archaeological metals. It is often impossible to reach ideal conditions due to lack of funding or to limitations of the physical building. We strive to reach a balance between these issues to achieve the best possible environment for all collections, including these sensitive collections, while living within budgets and building requirements.

Practical solutions for these challenges must be sought. They must be within budget and be easily maintained. This article explores the development of microclimate containers for humidity-sensitive collections. This series of solutions was developed at the Science Museum of Minnesota over a 15-year period, each solution building on the strengths of the previous. It is hoped that the reader will adapt these ideas to their own situations.

1. INTRODUCTION

In the late 1980s, the Canadian Conservation Institute (CCI) developed the Preservation Framework to help conservators and museum professionals develop reasonable strategies to solve challenges, such as this one (Michalski 1994; Rose and Hawks 1995). The Preservation Framework, together with formalized risk assessment for collections (Waller 1995), provided a broader, more practical way of identifying and mitigating risks to museum collections. It was a different way to think about the risks, one in which the conservator could make improvements in overall collections care based on specific situations and budget constraints. The Society for the Preservation of Natural History Collections (SPNHC) helped disseminate this information to conservators and collections managers in natural history collections.[1]

At the same time as this methodology was being disseminated, The Science Museum of Minnesota (SMM) founded a conservation department and hired its first conservator. The conservator was charged with the responsibility of developing a museum-wide conservation program that crossed all division lines. The methodology as described in the framework was immediately adopted as the founding principles of the department. It was used to address challenges to collections care, and was a natural fit with the philosophy and structure of the museum. The conservator could develop reasonable solutions for the serious problems of environmental control encountered at SMM.

The Science Museum of Minnesota has approximately 1.75 million collections, of which there are about 150 archaeological metals. The majority of these are Native American copper artifacts, and a collection of Etruscan bronzes. In 1989, collections at the Science Museum of Minnesota were stored in a large basement storage area. The cabinetry, considered state-of-the-art in 1960, consisted of painted metal shells with oak drawers and polyurethane foam gaskets. There was evidence of numerous minor floods and high humidity in the form of rust formation and tide lines on cabinets and walls. The metal rolling ladders were rusted. The gaskets were crumbling. Hygrothermographs, purchased through an IMS CP funded general survey, were placed throughout the museum. One was placed on top of cabinets in storage; another was placed inside of a cabinet. The data from hygrothermographs was not surprising, given the Minnesota climate and the 1960 building that housed the collection. Relative humidity fluctuated seasonally from 10% in the winter months to over 80% in the summer, with up to 40% short-term fluctuations when storms rolled through the area. The data from inside of the cabinet demonstrated that the cabinet and wooden drawers buffered environmental changes. Relative humidity inside the cabinet fluctuated seasonally from 35% to 65%, smoothing out the short-term fluctuations. Given the age of the building and HVAC zones the only reasonable action was to create microclimates.

The archaeological metal collections were often placed directly on the wooden drawers, with no barriers. They were minimally padded with acidic and hygroscopic materials such as polyurethane foam, cotton and acidic paper. There were no supports for the fragile metals that were in storage.

At the same time, there was a desire to put more collections on exhibition. Curatorial and exhibition staff wanted to create study storage drawers in order to allow the public to see more of what is in storage, and to put behind-the-scenes activities on exhibit. SMM was experimenting with methods of putting collections storage on display. To this end the storage cabinets and drawers were retrofitted so that drawers could be opened and closed at will by the public. The collections inside had to be "bullet proof": safe from theft and from banging drawers. They were safe from vibration and shock. These experiments brought about the first generation of microclimate drawers, and started us on the quest for improving storage for humidity-sensitive artifacts.

2. GENERATION 1: 1991

The drawers used were the actual drawers used in collections storage, placed in an actual storage cabinet (fig. 1). In addition to fluctuating relative humidity, we were attempting to overcome the following challenges: acid contamination from the drawer, object support, vibration mitigation, and security. As is typical in these situations, there was only a little bit of money available to do the work.

Construction instructions:

1. The oak study storage drawer (as it was called) was lined with Marvelseal, an aluminium plastic laminate, to mitigate acidic off-gassing from the oak drawer. The effect was tested using potassium permanganate and found to be successful.[2] Holes for the drawer pulls at the front and back of the drawer were sealed with a block of wood that was also covered with Marvelseal.
2. The bottom of the drawer was lined with polyethylene foam. An upper layer of foam was cut with cavities customized to fit the metal artifacts. The artifacts were held in place through pressure. Embroidery floss was used to secure any object that would not stay in its pressure-fit cavity.
3. Silica gel was conditioned to be as dry as possible and placed in muslin tubes. The tubes were pinned into place. A humidity strip was placed in the drawer to monitor conditions.
4. The drawer was sealed with a Plexiglas lid that was screwed into the wood and the seam was taped closed with clear packing tape.
5. A 2-inch pad of Ethafoam was attached to the back of the cabinet to buffer the shock when the drawer was slammed shut by the public.

Fig. 1. 1991: The first generation of microclimate container consisted of wooden storage drawers modified to reduce acidic contamination with Marvelseal (Photograph by Gretchen Anderson)

This method was crude but effective. The copper artifacts were held securely in place, the volatile acids off-gassing from the wood were reduced significantly, and a low relative humidity (about 20%) was maintained throughout the year. The objects were secure from theft behind Plexiglas. The silica gel had to be reconditioned every two years. The objects were completely visible yet secure behind Plexiglas. One drawer was prepared in this manner.

There was one major drawback. It was extremely difficult to access the artifacts. To remove an individual object for research or to remove the silica gel for reconditioning, the cover had to be completely removed. Since it was held in place with at least 20 screws, this was a tiresome and time-consuming activity. This made the method unacceptable for use on a collection that was actively being studied. To solve this problem we modified the drawer by cutting a channel into which the Plexiglas cover was slid. However, this modification could not be easily sealed against off-gassing and it was not tight enough to maintain the desired relative humidity.

3. GENERATION 2: 1994

Given the drawback of difficulty in accessing the collections and the fact that many of the Etruscan artifacts were too deep to enclose in a drawer, we took a slightly different approach for collection storage. Inexpensive polypropylene and polyethylene plastic tubs were purchased and put through Oddy testing[3] to ensure that they were inert (fig. 2). After the container was altered, it was tested again using potassium permanganate.

Construction instructions:

1. The bottom of the box was covered with conditioned silica gel. The volume of the specific box determined the amount of desiccated gel (Canadian Conservation Institute

1984). Small quantities of indicator gel were mixed in to quickly and easily monitor relative humidity.

2. The second layer consisted of polystyrene lighting grid, cut to size. This was set on blocks of Ethafoam so that it rested above the silica gel. The grid served a double purpose. The holes allowed for the air in the box to be desiccated and the structure was adequate to provide a base on which to construct a storage mount.
3. A storage mount made of Ethafoam and backer rod was lined with acid-free tissue, which was later upgraded to Tyvek. Each mount was made custom for the object, and could be adapted to best protect the piece.
4. A humidity strip was placed inside the container to monitor relative humidity (fig. 3).
5. The lid snapped on the box, but the seal was not adequate to maintain the desired relative humidity. This was improved by adding a silicone gasket, backed with acrylic adhesive. This material was purchased from a local hardware store. Clear 3M packing tape was used to further improve the seal. Several clear packing tapes were tested for chemical stability and for the ability to remain attached to the plastic container. Oddy tests were also done on the adhesive. The 3M packing tape was the most stable and had the best long-term adhesion to the plastic box. It begins to yellow after 10 years - about the time the silica gel requires reconditioning.
6. A photograph of the artifact was placed on the exterior of the lid for identification.

Fig. 2. 1992: The second generation container was a polyethylene/polypropylene storage container, purchased off the shelf at Target (Photograph by Gretchen Anderson)

This was a highly successful experiment. The original materials are inexpensive, inert, and provide full support for even the most fragile object. Relative humidity was held at the desired level, and was extremely stable for 10 years.

Nothing is perfect. It was hard to see the object. At the time, the only containers available were cloudy. Photographs were placed on the tops and sides of the boxes to identify the objects in the container. Today, many clear containers can be found which would partially solve this drawback. However, even with the clear containers, it is impossible to see the entire object without removing it from the microclimate box. While it was easier to get into than the study storage drawers, access was not ideal.

The objects placed in this system were a small collection (approximately 30 pieces) of Etruscan and Roman bronzes, and two metal bowls from Peru. That left the Native American copper artifacts without proper storage. This was a collection that was actively being researched and curators did not want them to be inaccessible in either system that had been prototyped. An attempt was made to make Marvelseal bags with Mylar windows; unfortunately it was almost impossible to make the bag completely tight so that humidity was maintained. No matter how carefully the bags were made there would be tiny holes, and a low relative humidity could not be maintained. It was also difficult to see the artifacts. Today, there is a wider range of plastic laminate materials that might be used to create a viable clear package.

Fig. 3. A humidity strip was placed inside the container for ongoing monitoring (Photograph by Gretchen Anderson)

4. GENERATION 3: 2001

Fast forward to 2001. The Science Museum of Minnesota had just opened a new museum facility with a state-of-the-art collections storage area in December 1999. SMM holds a relatively small natural history collection (1.75 million objects) and it was decided to maintain the tradition of placing all collections in one large, climate-controlled storage room. Delta Design cabinets placed on compactor units were used to fully maximize space in the storage facility (fig. 4). Conditions in storage are maintained at 68°F ± 2° variance and 45% RH ± 5% variance. This was a definite improvement over the previous storage facility in a damp basement.

But, what to do with smaller collections that should be stored at lower (or higher) relative humidity levels for their long-term preservation? SMM does not have a large enough collection of archeological metals requiring specialized environmental conditions to justify the expense of a special room. A specially adapted cabinet was the ticket. All the archaeological metals could easily be placed within a single cabinet. An active system was briefly considered, but determined to be more prone to failure than passive systems.

Fig. 4. 2003: The third generation of microclimate drawer is a customized Delta Design drawer (Photograph by Gretchen Anderson)

A conservation team consisting of the conservator (Anderson), assistant conservator (Rebecca Newberry), and a volunteer who happens to be a retired engineer (Ron Voelker) discussed methods to adapt the new Delta Design drawers along the concept of the 1^{st} generation study storage drawer. The challenges were different than with the old wooden drawers. The powder-coated surfaces of the cabinets and drawers were already inert. However, the folded metal drawers have gaps in them that had to be filled. The biggest problem was how to provide a leak-proof seal around the Plexiglas cover.

We tested a few systems and came up with the following method:

1. The drawers have gaps and holes in them. These gaps were with filled with silicone caulk (ammonia free). The caulk was allowed to cure fully for a month.
2. A silicone gasket with an acrylic pressure-sensitive adhesive was applied to the flange on the top of the drawer. This acts as a seal (if silicone gasket is not available, Volara foam cut into strips and attached with 3M pressure-sensitive adhesive 968 works well). The gasket that was used had a solid, rectangular cross section, although other profiles could be used. Testing the sealing capability of each profile prior to use is recommended. The

gasket used was chosen after discussion with Delta Design engineers and extensive Oddy testing.

3. Plexiglas was cut to cover the top of the drawer. Quarter-inch Plexiglas was chosen because it was thick enough not to deflect over the surface of the drawer and there happened to be a supply from a prior exhibition that could be reused. It was scratched, but acceptable for use in storage. It was secured with two clamps made of Plexiglas on the front of the drawer and metal clamps on the back. The metal clamps were made from aluminum U channel (figs. 5–7). After much experimentation, it was found that two simple clamps on the back were adequate to maintain a seal. The metal clamps have a setscrew that can be slightly tightened as needed. Do not over tighten the screws or wing nuts. This will stress the seal and break it, allowing the modified environment inside the case to equalize with the ambient atmosphere (fig. 8).

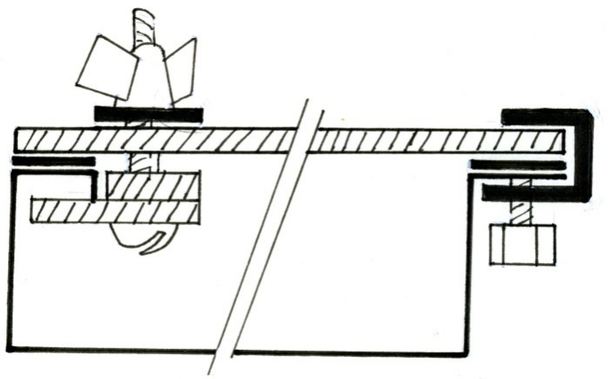

Fig. 5. The diagram illustrates the systems used to clamp the Plexiglas on to the metal drawer. There is a flat silicone gasket between the drawer and the Plexiglas.

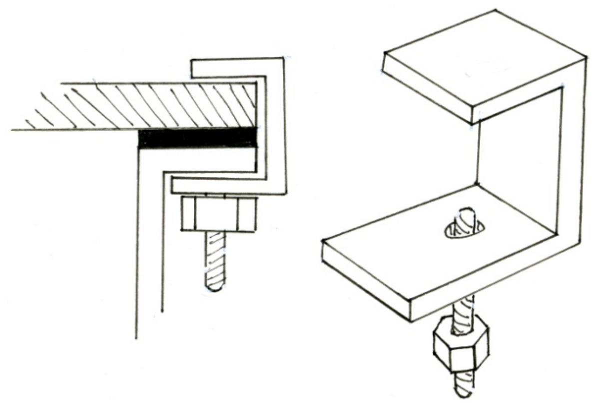

Fig. 6. The clamp on the back of the drawer is made of an aluminum U channel with a threaded rod and nut. The black line on the diagram is the flat silicone gasket. The pressure applied by the clamp is minimal.

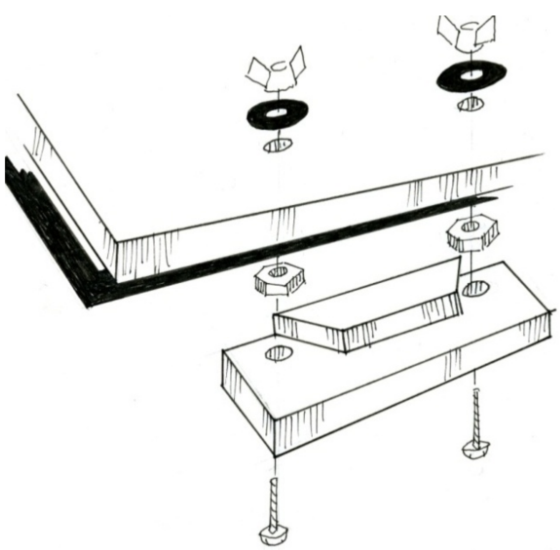

Fig. 7. The front clamp is made of a series of Plexiglas pieces that fit over the lip of the drawer. Threaded bolts, nuts, ring gaskets and wing nuts are finger-tightened to apply pressure needed to seal the container.

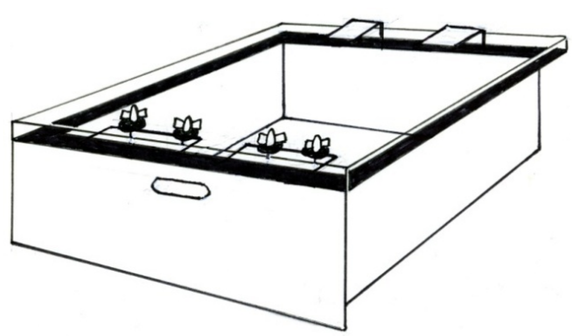

Fig. 8. The finished drawer.
For figures 5–8: Design by Ronald Voelker
(Illustration by Verne J. Anderson)

4. Student interns were instructed to created modular cavity mounts for each individual object. In this way the artifacts could be organized according to the archaeologist's needs. The cavity mounts were made with a corrugated plastic (polypropylene) base, polyethylene foam, backer rod/tri-rod supports and padding. Tyvek was used to line the mounts. They fit into the drawer like a puzzle. Magnets were used to keep the mounts from sliding on the slick surface of the drawer.
5. Bulk silica gel was packaged in cotton stockinette and conditioned to be as dry as possible. To condition, the tube is simply placed in an oven at 50°C and baked for 3-4 hours. The cotton stockinette was tested prior to doing this and was not damaged by the process.
6. A humidity monitor was placed in each drawer.

The test drawer held 10% relative humidity for five years (as of 2009). The collections are easy to see in the drawers. Curator or researcher can do all preliminary examination through the Plexiglas using catalog information. If further work is needed, the artifact can be easily and quickly removed from the drawer with minimal impact on the environment. The silica gel can be easily removed for reconditioning when necessary.

The museum's metals are now stored in a low relative humidity environment that is very stable. There is no contamination from the drawer or from storage materials. All of the microclimate drawers are currently stored in a single cabinet, and not integrated into the traditional organizational system. The reasoning behind this was that it would be easier to monitor the microclimate if all drawers were grouped together, and it was a more efficient use of space.

5. VARIATIONS ON A THEME

Other uses for the drawers have been found. Like many natural history collections, SMM has a collection of historic bird study skins and taxidermy. These date to the early days of the 20th century, and it was no surprise to find that they are laced with arsenic. The microclimate drawer system was used to isolate and contain the contaminated specimens (fig. 9).

It took some convincing to get the collections manager to agree not to integrate the birds into the usual taxonomic organization of the collection. In the old facility the historic collection had been segregated in a mobile storage cart. When the collection was moved to the new facility, the collections manager began to integrate the arsenic-laden specimens into the taxonomic order with modern study skins. Conservation expressed concern of cross-contamination. This was demonstrated by testing the specimen adjacent to the contaminated specimens, as well as testing the foam liner. The presence of arsenic was tested using the standard arsenic spot test.[4]

Once the possibility of cross contamination was clearly demonstrated, the collections manager was satisfied to segregate the historic collection. The arsenic is now contained and not in danger of contaminating other specimens. The collection is easy to find and easy to view, and there is no doubt as to what specimens are contaminated and should be handled with care.

Fig. 9. This method has other uses beyond creating controlled relative humidity containers. The same system has been used to contain bird study skins that are laced with arsenic. In this manner the skins are isolated, preventing cross-contamination with specimens not treated with arsenic, and a healthier environment for researchers working with the collection is provided. (Photograph by Gretchen Anderson).

6. CONCLUSION

Each one of the microclimate drawers worked. They did the job, and were all reasonable and affordable. Our solutions were for Kewaunee and Delta Design cabinets. However, the methods can be adapted for use with other types of drawers and cabinets.

As conservators we are faced, sometimes daily, with seemingly impossible tasks. There is almost always a reasonable solution to the problem. This is good to remember on those frustrating days when everything seems to backfire. Take a deep breath. Look at the Framework for Preservation (or your problem solving tool of choice) and work it out. Be practical about the solution. With a little ingenuity, imagination and creative help we can solve almost any storage challenge.

ACKNOWLEDGEMENTS

A good team is vital for a creative project like this. The best team should have a broad range of experiences and expertise. An interesting and successful design comes only after experimentation and creative thought. The success of this project came about because of creative discussion and experimentation, and the willingness to change. The author would like to thank the following individuals for their invaluable input: Rebecca Newberry, assistant conservator, Ron Voelker, retired engineer and volunteer (every conservation lab should have access to a retired engineer to build the ideas conservators come up with), Verne Anderson, volunteer and artist (an artist who can clearly render constructions is invaluable - all of the drawings in this paper are by Verne Anderson), Jim Krache, conservation volunteer, who constructed mounts and helped to make enclosures, and interns (who seem to do the bulk of the work): Malcom Collum (1991–1993), Tracey Bredehoft (1991–1993), Kristine Hansen (1996–1997), Megan Emery

(2000–2001), Margaretta Kuesch (2002–2004), Giovanna Fregni (2004–2007), and LeeAnn Barnes Gordon (2006–2007).

NOTES

1. The matrix is no longer available on line. However, CCI has published a series of excellent articles (www.cci-icc.gc.ca/caringfor-prendresoindes/articles/10agents/index-eng.aspx), providing methods and information to systematically mitigate risks to collections through the use of layered strategies.

2. The use of potassium permanganate pellets (Carusorb) can be used as a quick "spot" test to determine if an enclosed area, such as a cabinet or exhibition vitrine, has organic contamination (Ballard and Erhardt 1990). A few beads are placed on a watch glass. The area is closed and left for 24–48 hours. If the bright purple beads turn a dull brown there is contamination. This will not tell you what the contaminant is – just that there is contamination. All enclosures have been tested using this method along with testing using A-D strips (Nicholson and O'Laughlin 1996; Alten 1997).

3. The Oddy test referred to in the text is the accelerated aging test originally developed by Andrew Oddy for the British Museum. The methodology Anderson uses was learned at the 1990 Display Materials Workshop at the then Conservation Analytical Lab Smithsonian (Ballard 1990). Since that time she has used it to test the suitability of many materials for storage and exhibition.

4. The Conservation Department at the Science Museum of Minnesota has traditionally used the arsenic test first published in Leather Conservation News (Hawks and Williams 1986).

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SOURCES OF MATERIALS

3M Packing Tape, 3M Jet-melt hot melt ATG (924, 926, 969, 987) and Double stick tape (415) (when purchasing these products look for acrylic adhesive, and polyester carrier).
3M Shop
www.shop3m.com

Aluminum U channel, screws and other hardware, silicone caulk (ammonia free), silicone gasket with 3M adhesive backing [No particular brand name is specified. Choose the profile that works best and run Oddy tests on it. One option is to use Volara or other closed-cell, conservation-grade foam and apply 3M acrylic adhesive tape (986)].
Grainger
www.grainger.com

Carusorb
Museum Services Corporation
385 Bridgepoint Way
South St. Paul, Minnesota 55075
(651) 450-8954
www.museumservicescorporation.com/index.html

Cotton Stockinette
Mountain Medical Equipment
9262 Old River Road
Marcy, NY 13403
(888) 687-4334
www.mountainside-medical.com/products/Cotton-Tubular-Stockinette,-Non-Sterile.html

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BLOW IT OFF: MOVING BEYOND COMPRESSED AIR WITH CARBON DIOXIDE SNOW

L. H. (HUGH) SHOCKEY JR.

ABSTRACT

Carbon dioxide snow cleaning has advanced significantly in recent years, making it an affordable and consumer-friendly surface cleaning method. The technology has been tested and used in critical cleaning applications, such as the removal of surface contamination during the production of silicon microchip wafers and precision optical lenses. Carbon dioxide snow cleaning is an emerging technology in conservation with the possibility of aiding in the cleaning of sensitive surfaces.

Robert Morris' molded plastic sculpture *Model*, 1967 was requested for loan from the Smithsonian American Art Museum's collection. As part of the loan process, the work was examined and a whitish surface haze was readily visible that disfigured the appearance of the work. After careful consideration, carbon dioxide snow cleaning was chosen as the treatment method to address the surface condition. Carbon dioxide snow proved to be an effective and efficient method of reducing the appearance of the disfiguring haze without bringing solvent or aqueous cleaning systems to the surface of the sculpture. The results from the cleaning of Robert Morris' *Model*, 1967 suggest that carbon dioxide snow cleaning may provide a useful tool for the conservator's toolbox with the potential to address cleaning problems and ongoing maintenance of objects with sensitive surfaces.

1. INTRODUCTION

The Smithsonian American Art Museum (SAAM) collects, exhibits, and loans works by American artists with works spanning the history of the United States. The museum actively loans works from its collection to disseminate knowledge of American art and artists. A request to borrow Robert Morris' *Model*, 1967 from the SAAM collection prompted examination of the work. *Model* is a molded plastic wall sculpture from a series of multiples in the style of the minimalist movement of the late 1960s. During initial examination, a white haze was apparent on the surface of the sculpture that detracted from the minimalist aesthetic of the work. Microscopic examination revealed that the haze was the result of small crystalline deposits on the surface of the polymer. To properly represent the artistic intent of the work during exhibition, the white disfiguring haze would need to be removed.

Several methods of removal were considered. Traditional mechanical surface cleaning posed the risk of scratching the smooth surface of the work. Aqueous or solvent cleaning could remove the material; however, it could also cause problems with the polymer's structure, potentially increasing its crystallinity. Carbon dioxide (CO_2) snow was also considered as a third possibility since the technique could provide the benefits of mechanical cleaning while reducing the potential for damage. After testing of these various methods, carbon dioxide snow was chosen to remove the crystalline deposits that caused the visible white haze.

1.1 CARBON DIOXIDE SNOW

Carbon dioxide snow is the single crystalline solid form of carbon dioxide. CO_2 snow should not be confused with commercially produced dry ice. Dry ice is the macro form of solid carbon dioxide found in pelletized forms that are millimeters in scale. By contrast, carbon dioxide snow crystals are micrometer (micron) size particles (Hill 1994, 36). Understanding the particle size is important since the primary cleaning mechanism of CO_2 snow is momentum transfer, whereby momentum is the relationship between mass and velocity (Cano 2001, 330). Carbon dioxide snow cleaning uses the low mass of the solid crystal at high velocity. Carbon dioxide snow's advantage over compressed air is due to the ability of the micron-sized snow particle to penetrate the turbulent air boundary layer that is approximately 3 microns thick and present on the surface of all objects in the atmosphere (Sherman 2007, 40). Penetrating this boundary with the physical particle allows for momentum transfer to displace surface soiling.

In addition to momentum transfer, several mechanisms are thought to contribute to the cleaning efficacy of CO_2 snow. These are the solvent effect that carbon dioxide has on hydrocarbon soiling, and the theoretical effects of temperature depression commonly referred to as "freeze-fracture" in the literature (Cano 2001, 331-333). The term "freeze-fracture" suggests freezing temperatures. However, anecdotal testing using a FLIR 320EX thermal imaging camera with the CO_2 snow jet directed at and impacting the lens revealed the lowest temperature to be 46.6°F (8.1°C), far from the freezing point of water (fig. 1).[1]

Fig. 1. The display screen of the FLIR unit showing the low temperature value of 46.6°F. The black spot on the screen is the CO_2 snow jet in direct contact with the instrument's lens. (Photograph by Shockey)

1.1.1 Making Snow

Presently, a limited number of methods produce carbon dioxide snow. The current technology of production incorporates a nozzle with specific internal geometry and a CO_2 source. The geometry of the nozzle and the type of source directly influence the efficiency of snow generation, the snow crystal size, and the size of the cleaning area (Cano 2001, 331). The most common nozzle geometries can be characterized as either single expansion or double expansion types (Sherman 2007, 44). While other designs exist, they lack the constant enthalpy conditions that allow them to be used with both CO_2 liquid and gas sources and lack efficiency in the generation of snow particles.

Either liquid or gaseous CO_2 can be used to generate CO_2 snow. Liquid source generation offers the advantages of producing great quantities of particle and large particle sizes; however, it also has the disadvantage of inefficient snow formation in comparison to source consumption. In addition, it has the potential to carry contaminates from the compressed gas cylinder solubilized by contact with the liquid CO_2. Gas source generation offers the advantages of low contamination, high efficiency in relation to source consumption, and production of a finely focused crystal stream; at the same time, it lacks the displacement ability of larger crystals and the large volume of crystals generated with a liquid source (Hill et al. 1999, 29-30).

With CO_2 snow cleaning, the efficiency of crystal formation can be enhanced with the addition of a moisture-displacing cover gas or warmed air (Sherman 2007, 46). A moisture-displacement gas can be integrated into the snow generation nozzle or can be supplied via a secondary system. The snow unit used at the Lunder Conservation Center is a purpose-designed dual gas unit that allows the moisture-displacement gas, or cover gas, to be delivered coaxially with the snow stream (fig. 2). Other moisture-displacing methods used in the conservation laboratory with CO_2 snow include a dry inert gas supplied non-axially or warm air from a hot air gun used to flood the surface to be cleaned. Nitrogen (N_2) is a good choice of cover gas since it is non-flammable, relatively inexpensive and is supplied dry in a compressed cylinder. The snow unit at the Lunder Conservation Center uses a dry nitrogen cover gas that can also be heated above room temperature via a temperature controlled in-line heated hose.

Fig. 2. Detail of the co-axial nozzle. The center hole in stainless steel is the CO_2 snow exit. The multiple holes in the white fluoropolymer are N_2 cover gas exits. (Photograph by Shockey)

1.1.2 Considerations for Choosing CO_2 Snow for Cleaning

The primary considerations for choosing CO_2 snow as a cleaning method are: (1) the type of soiling to be removed, (2) the surface to be cleaned, (3) the effect of temperature depression on the material to be cleaned, and, (4) the ability of the object to be cleaned to withstand the force of the CO_2 jet.

Research has shown that CO_2 snow cleaning is most effective for the removal of non-covalently bound particulate material from the surface of solid, minimally energy absorptive substrates (Hill 1994, 39; Sherman 2007, 42-43). As with all cleaning systems, the parameters for use can be pushed, but the efficiency and effectiveness will be impacted. For momentum transfer to be effective as a method of cleaning, the soiling to be removed must have a bond energy with the substrate that is weaker than the energy transferred by the snow particle (Hill 1994, 38-39). Surfaces that are minimally energy absorptive, that is, materials considered "hard" or "glassy," will be cleaned more effectively since the energy of the snow crystal will not be lost by absorption and dissipation into a "soft" surface (Sherman 2007, 50-52).

Thermal conductivity and the response of the material to be cleaned to temperature depression must also be carefully considered. Materials with high thermal conductivity have the potential to quickly condense atmospheric moisture on the surface if the temperature crosses below the dew point. Condensation can be mitigated with the use of a dry cover gas. Additionally, this gas can be further heated to manipulate the localized dew point (Cano 2001, 333). The temperature depression caused by the cold temperature of the CO_2 snow jet must be considered for materials that have critical glass transition (T_g) temperature points close to room temperature. Materials considered for cleaning with CO_2 snow must be able to withstand the force of the jet that delivers the snow crystals to the surface. Every CO_2 snow generation unit will have a different maximum jet velocity between 3 and 100 meters per second (m/s) (Sherman 2007, 44). The Lunder Conservation Center's CO_2 snow unit has a maximum recorded velocity of 46.9 m/s (fig. 3).

Fig. 3. Velocity testing in the conservation lab. The white CO_2 snow jet can be seen between the end of the nozzle and the entrance of the meter. (Photograph by Shockey)

Several additional factors are worth considering when evaluating the use of CO_2 snow as a cleaning method. These include: (1) the re-deposition of displaced soiling back onto the cleaned surface, (2) the generation of a static charge on the surface of some materials, (3) safety issues, and, (4) user experience.

As CO_2 snow is a momentum transfer and displacement cleaning method, the soiling material is ejected from the surface without an active capturing method, such as vacuum suction or air extraction. Consequently, the soiling particle will be deposited where it lands (Cano 2001, 334). There are several techniques that can be used to control this problem. Conscientious technique during cleaning is the first method of effective control. This consists of deliberately working from areas that have been cleaned toward areas that are soiled, often from the center of an object towards the outer perimeter. Ejected particulate soiling matter can be captured using sticky mats of various sizes available from clean room suppliers and by the use of a suction apparatus (i.e. a vacuum or fume extractor) placed on the far side of the blast direction.

The kinetic reaction of particulate removal from momentum transfer will have the secondary effect of elevating the potential energy on the surface of some material types (Cano 2001, 334). This becomes evident through increased static charge on the cleaned surface. This static charge can easily be mitigated with the use of an anti-static generator nozzle fitted to an air supply. The nozzle is usually a dedicated unit utilizing a compressed gas or ambient air source. The snow unit at the Lunder Conservation Center has an in-line, anti-static unit that is part of the nitrogen cover gas supply.

As with any treatment method, proper safety should be considered. Carbon dioxide snow presents several possible safety concerns: (1) it creates a CO_2 rich environment that can cause asphyxiation in an enclosed space without air exchange, (2) it can produce flying debris at elevated velocities requiring both proper eye protection and inhalation protection, (3) the high velocity jet can produce high decibel level noise, particularly when it encounters changes in topography on a surface, which requires the use of hearing protection (Cano 2001, 335-336).

User experience contributes significantly to the speed and quality of cleaning. An experienced user can minimize the occurrence of condensation and re-deposition of soiling material onto the cleaned surface and can quickly judge how effective CO_2 snow will be on an object to be cleaned.

2. ROBERT MORRIS' *MODEL*, 1967

Robert Morris's *Model* from 1967 is one in a series of 200 molded sculptures of cellulose acetate butyrate (CAB) and is 23 1/8 x 19 3/8 x 1 1/4 inches (58.7 x 49.1 x 3.1 cm) in dimension (fig. 4). The sculpture is the monochrome green color of the polymer. Overall, it is rectangular in shape with a raised circular form in the middle, reminiscent of a doughnut or life-preserver ring. Two of the four edges, one long and one short, have two concave depressions that correspond, spatially and conceptually, to the raised center ring. The signature and number are engraved into the polymer matrix on the back along the lower turned edge of the sculpture. The cellulose acetate butyrate substrate is a continuous sheet with a thickness of 2 mm. Yvonne Shashoua of the National Museum of Denmark identified the polymer composition from thin samples using Fourier Transform Infrared Spectroscopy (FTIR).

When examined as part of the loan request process, the sculpture was found to be in a structurally stable condition. The primary condition issue identified was the sculpture's aesthetic appearance. Surface dirt and grime, an overall white haze, and both fine and deep surface scratches impacted the appearance. The most visually significant of these conditions was the presence of the whitish haze on the surface. Examination of the haze under the stereo binocular microscope revealed that the haze was composed of small crystalline deposits that appeared smooth on their surfaces (fig. 5). Raking light examination under magnification showed that the deposits were raised above the surface. While the deposits were scattered over the surface, heavier concentrations were evident around changes in surface topography inside and outside of the central ring form. Samples of the deposits were taken from several areas on the surface using sterile cotton swabs and packaged in glass vials. These samples were sent to Yvonne Shashoua for analysis. Identification of the composition of these deposits has thus far been inconclusive.

Fig. 4. Before-treatment image of the sculpture. The streaks in the center are indicative of the white deposits. (Photograph by Shockey)

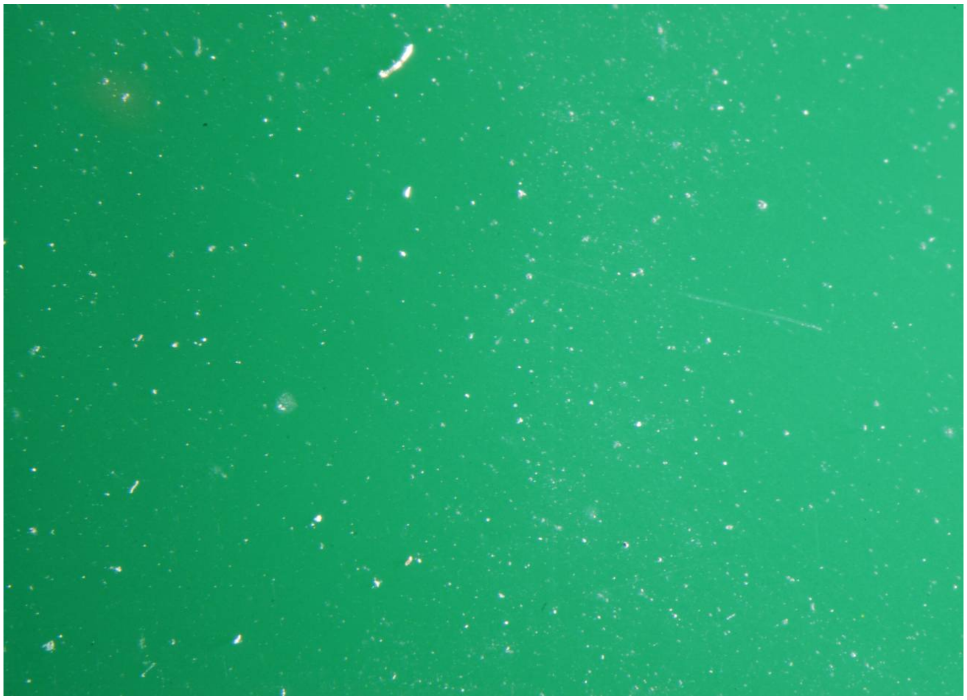

Fig. 5. The surface of the sculpture at 60x showing the crystalline appearance of the white deposits (Photograph by Shockey)

2.1. TREATMENT OF *MODEL*

The treatment of Robert Morris's *Model* was undertaken to correct the aesthetic deficiency of the sculpture, making it suitable for exhibition as an example of high minimalist art (fig. 6). In approaching the treatment it was necessary to consider the potential impact of cleaning on the polymer matrix. Without clear confirmation of the composition of the white deposits on the surface it was hypothesized that it could be plasticizer that had migrated out of the CAB polymer matrix. Testing indicated that aqueous cleaning might be possible since the white deposits appeared to be water soluble. The use of an organic solvent system was not pursued due to the potential for damage to the polymer. Consideration was given to current research on the conservation treatment of plastic materials; this research suggests complete removal of migrated plasticizer and other modifiers from the surface of a polymer may contribute to additional migration, further altering the internal composition of the plastic (Shashoua 1998, 175, 209). With this in mind, CO_2 snow was considered and tested.

The results of the test showed that the deposits were reduced to the point of invisibility under normal viewing conditions (fig. 6), but microscopic remnants were visible when examined under magnification (figs. 7-8). Careful consideration was given to the possible effects of temperature depression on the polymer. Testing was conducted with the CO_2 unit to determine the low-end temperature range of the jet using a Fluke 561 HVAC Pro non-contact infrared thermometer. The lowest surface temperature recorded during the momentary blast of the CO_2 snow jet on the surface was 47°F (8.3°C) with a rapid return of the surface to ambient temperature. Potential damage from the force of the jet was also considered. This concern was mitigated with the use of a polyethylene foam insert on the reverse of the sculpture to prevent possible deformation of the polymer during cleaning.

With these concerns addressed, and with the knowledge that CO_2 snow cleaning could provide a dramatic improvement to the aesthetic appearance of the work without entirely removing the deposits, the decision was made to move forward with snow cleaning as the treatment method. The pre-existing physical damage to the surface in the form of scratches and abrasions was deemed aesthetically acceptable since invasive alteration and removal of original material from the surface by polishing would have been the only treatment option, and research has shown that such surface alteration can have a negative impact on the long term preservation of the plastic material (Shashoua 1998, 213).

Fig. 6. After-treatment image of sculpture with no apparent surface deposits (Photograph by Shockey)

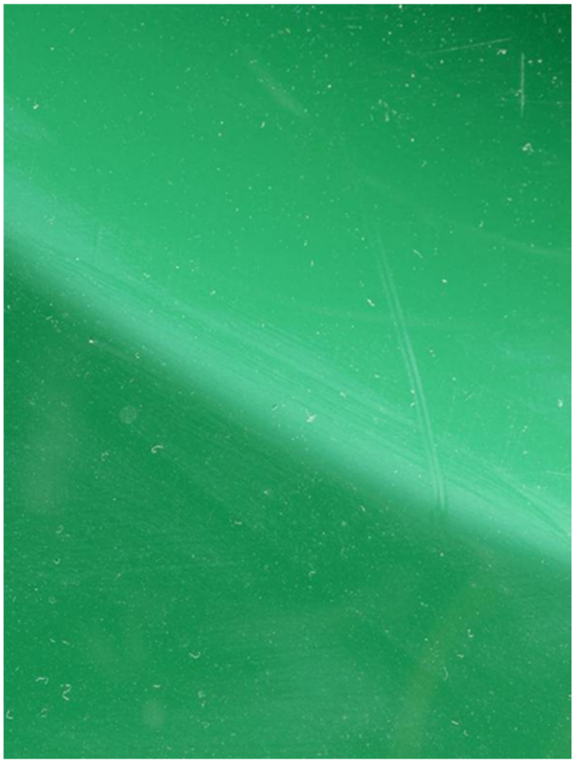

Fig. 7. Appearance before cleaning at 10x
(Photograph by Shockey)

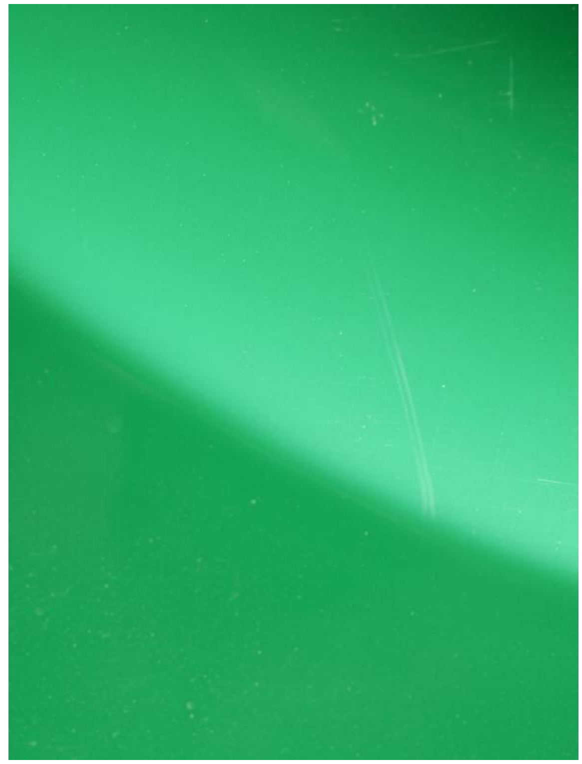

Fig. 8. Appearance after cleaning at 10x
(Photograph by Shockey)

The removal of the deposits was approached in a systematic manner. With the foam support in place, the sculpture was placed face-up on the treatment table with a Nederman fume extraction trunk on the far side of the treatment area for particulate collection. With the nitrogen cover gas activated, the CO_2 snow nozzle was directed at the surface. A broad circular motion was made with the nozzle at roughly 90 degrees to the plane of the object, and a sustained blast of CO_2 snow, emitted approximately 12 inches (30.5 cm) above the sculpture, was used to "pre-chill" the surface. This technique has been found to assist in mitigating the potential for condensation. The nozzle was brought closer to the surface at the center of the sculpture with an angle of 45 degrees or less to the surface. Intermittent blasts of the CO_2 snow jet were used for active cleaning. With this technique, removal of the white deposits commenced. A side-to-side sweeping action was used in addition to the intermittent snow blasts. Beginning in the center, cleaning continued with a steady movement outward toward the edges of the sculpture. Care was taken during cleaning to overlap each sweep of the CO_2 snow jet with the previous when moving the cleaning front forward (i.e. as when spray-painting a surface). The sculpture was moved and rotated on the treatment table to maintain alignment with the fume extractor on the far side and the direction of the blast. Areas needing additional attention were approached in the same manner as the overall cleaning. A final overall pass was executed from the center outward to ensure all residual debris was removed from the surface. As a follow-up to the final pass, the anti-static generator was activated in the nitrogen supply line and a stream of deionized nitrogen was passed over the surface in broad sweeping strokes with the nozzle held at approximately 90 degrees to the surface. The total active treatment time for the *Model* was less than one hour and resulted in significant visual improvement of the work.

2.2. EVALUATION OF CO_2 SNOW TREATMENT

To compliment the perceived aesthetic improvement of the work following treatment with CO_2 snow, Yvonne Shashoua provided information regarding the treatment's effect on the structure of the polymer substrate. To facilitate this analysis, the reverse of the sculpture was cleaned in the same manner as the front. Ms. Shashoua provided instructions for removing thin-section samples from the plastic substrate for testing the effects before and after cleaning. Following these instructions, SAAM conservator L.H. (Hugh) Shockey, Jr. removed the thin-section samples from the reverse of the sculpture with a sharp micro chisel and packaged them for mailing. Ms. Shashoua ran attenuated total reflectance (ATR) at a resolution of 4 cm^{-1} over 20 scans using a Durasampl IR ATR with diamond crystal on the thin-section samples, one before treatment and one after treatment. The results of the test showed no noticeable difference in reflectance between the samples. This suggests that the temperature depression and the force of the CO_2 snow cleaning did not have an effect on the physical structure of the polymer matrix (fig. 9).

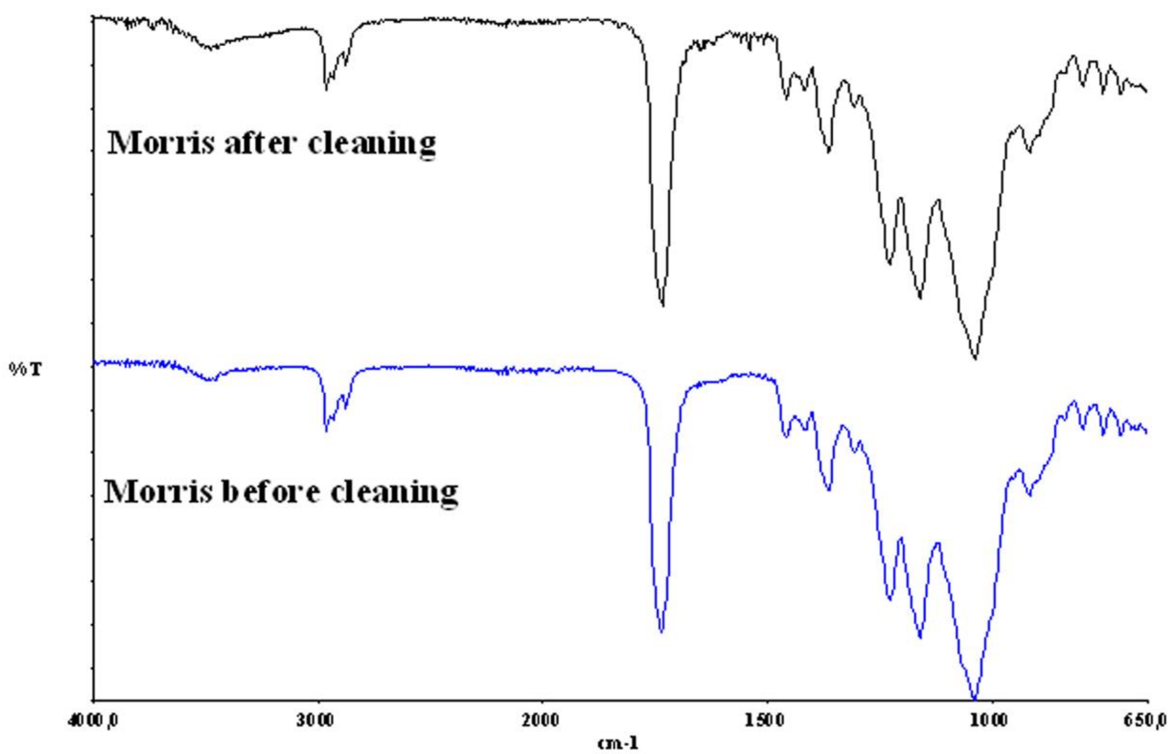

Fig. 9. Spectra produced from the ATR analysis conducted by Yvonne Shashoua

3. MOVING FORWARD WITH CO_2 SNOW

Carbon dioxide snow is a cleaning tool for the conservator's toolbox with its greatest potential yet to be realized. Bench-top anecdotal experimentation suggests that it may be a viable cleaning alternative on a diverse number of materials and object types. Like any tool, it cannot solve all problems and the choice to use the method must be carefully considered. If the general parameters of successful use are observed, CO_2 snow could prove to be a useful cleaning solution for a wide variety of materials. The most important of these parameters to observe are: the soiling type should be particulate or light-hydrocarbon in nature; the surface to be cleaned should be minimally energy absorptive; and the object to be cleaned should not be detrimentally affected by the momentary temperature depression or force produced by the CO_2 jet. Identification of the potential combinations of soiling type and material to be cleaned in the field of conservation has only just begun. The sharing of knowledge from continued experimentation and use of the system will help to facilitate the conservator's understanding of CO_2 snow's effective application to cultural materials.

ACKNOWLEDGEMENTS

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NOTE

1. Testing was done in the SAAM Object Conservation Lab in cooperation with Anthony Dessasso, Engineer, of the Smithsonian's OFEO (Office of Facilities Engineering & Operations), custodians of the FLIR imaging unit.

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FURTHER READING

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SOURCES OF MATERIALS

Nitrogen gas and CO_2 snow unit with gas or liquid CO_2 feed
Applied Surface Technologies
15 Hawthorne Drive
New Providence, NJ 07974

CO_2 snow unit with liquid CO_2 feed
Va-Tran Systems Incorporated
677 Anita St, Suite A
Chula Vista, CA 91911

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MINIATURIZED COLD ATMOSPHERIC PLASMA FOR IMPROVING THE ADHESION PROPERTIES OF PLASTICS IN MODERN AND CONTEMPORARY ART

ANNA COMIOTTO

ABSTRACT

This paper reports on the development of a plasma-pen that opens up new possibilities for overcoming adhesion problems during small-scale conservation and restoration treatments on non-polar plastics in modern and contemporary art. The setup of the developed plasma equipment will be described, as well as today's state of knowledge concerning the effectiveness of the plasma pre-treatment to enhance the wettability, bondability and coatability of polyethylene, polypropylene, and polystyrene. The extent to which the pre-treatment enhanced the bondability was evaluated by performing tensile shear tests on untreated and plasma pre-treated adhesive bonds. These bonds were made on polyethylene and polypropylene with the acrylic resin Paraloid B-72. Improvements in coatability were examined in pull-off tests carried out on gouache-painted polyethylene and polystyrene.

In the case of all plasma pre-treated, non-polar plastics, the plasma pre-treatment resulted in a significant improvement of adhesive qualities. The breaking forces necessary to separate all tested adhesive bonds were significantly increased, and the tested gouache coatings gained a considerable mechanical resilience. This has interesting implications for conservation practice: adhesive bonds and retouchings with high mechanical resilience can be applied on the plasma pre-treated surfaces, helping to prolong the expected lifespan of conservation measures. Furthermore, the application of mechanically resilient, water-based and water-removable gouache retouchings on hydrophobic plastic surfaces becomes feasible. An essential chemical mechanism during plasma treatment is surface oxidation. This was proved on plasma pre-treated polypropylene by using infrared spectroscopy in attenuated total reflection. Little is known about whether or not this surface oxidation negatively affects the oxidation stability of the pre-treated materials. Chemiluminescence analysis was used to expand the knowledge about this issue.

1. INTRODUCTION

Non-polar plastics in modern and contemporary art are well-known to have insufficient adhesion properties in contact with nearly all types of adhesives or coatings.[1] Their surfaces are difficult to wet, their adhesive bonds have only limited tensile strength and applied coatings do not possess high mechanical resilience. In consequence of these unfavourable adhesion properties, long-lasting conservation treatments (e.g. paint layer consolidation, bonding or retouching) are often not possible or limited to art objects made of non-polar plastics. A well-known reason for their insufficient adhesion properties is a lack of surface polarity. Surface polarity is an important contributor to strong adhesive forces between plastics and adhesives (Kinloch 1987). To overcome this lack of surface polarity before paint layer consolidation, bonding or retouching, a pre-treatment of the plastic surface is necessary to provide it with an artificial polarity. It is well known from large-scale industrial applications that plasma technology offers an opportunity to enhance the surface polarity of plastics in order to improve their wettability, coatability and bondability (Gatenholm et al. 1990; Morra et al. 1990; Brewis and Mathieson 2002). Under specific operating conditions plasma pre-treatment can introduce polar chemical groups on non-polar polymer surfaces, for example by incorporating oxygen in the polymer's hydrocarbon chains, as observed by various authors who have used surface-sensitive analytical techniques (Gerenser et al. 1985; Wang et al. 2008; Leroux et al. 2008). This chemical modification is usually limited to the top few molecular layers of a polymer’s surface (Wu 1982, 298). The goal of this research study, which started 2006, was to develop a miniaturized atmospheric plasma-pen specifically designed for improving the adhesion properties of non-polar plastics in modern and contemporary art. The setup of the developed plasma equipment will be described and experimental results will be presented concerning the effectiveness of the plasma pre-treatment for enhancing the wettability, bondability and coatability of polyethylene (PE), polypropylene (PP), and polystyrene (PS). Furthermore, an experimental setup will be outlined for the evaluation of the long-term oxidation stability of plasma-treated polymers by chemiluminescence analysis.

2. PROTOTYPING THE PLASMA SOURCE

The plasma-pen was designed to meet the following demands: (1) the plasma should be locally applicable within a millimetre range at atmospheric pressure, therefore allowing small-sized and localized surface modifications, (2) the plasma should achieve a homogeneous, reproducible and effective improvement of the polymer's adhesive qualities, (3) the thermal load, which is caused by the plasma, should be kept on an adequate low level on thermoplastic surfaces, and (4) the pre-treatment should not accelerate the long-term ageing of the pre-treated plastics and surrounding materials (e.g. paint layers). In addition to these demands the plasma equipment should be as low-priced as possible, while maintaining high durability of the used materials.

A variable AC transformer, coupled to a matched, low cost high-voltage circuit serves as power supply (1). The main part of the pen-shaped plasma source (3) is an alumina capillary (4), within which the plasma is generated. A cross-section through the capillary (5) shows the concentric electrode configuration (a-d). If adequate high-voltage is applied in this capillary, electrical discharges are formed in the gap between two electrodes (b and d). The primary high voltage electrode (b) is a thin metal wire, mounted coaxially in the centre of the capillary. A metallization layer (d) serves as secondary, grounded electrode. The alumina capillary (c) for its part acts as a dielectric layer between these two electrodes and prevents hot and non-homogenous arcing. An operating gas (e.g. pure helium or helium with the admixture of oxygen) is fed into the capillary by letting it pass through a supply pipe (2). The throughput of the gas can be regulated with flow control units. Provided that the plasma is produced within a suitable high voltage and frequency range, and provided that a suitable gas flows with an adequate flow rate through the capillary, a plasma-jet effuses that can be used for surface pre-treatment. This plasma source produces a so-called *dielectric barrier discharge*, which allows the production of non-thermal plasma at atmospheric pressure (Napartovich 2001). During plasma generation, electrons and gas particles are colliding with each other inside the capillary, whereby the operating gas becomes partially ionized and charged with chemically reactive particles. This chemical reactivity, caused by free radicals, can be used for chemical surface modification.

For all the experiments reported in this study, plasma pre-treatments[2] were carried out using a computer-controlled, step-motor driven x-y plotter, shown in figure 3. This plotter, fitted with a sample platform, was used to obtain reproducible pre-treatment speeds. It moved samples (PE, PP and PS) along the x- and y-axes across a pre-treatment area of 10 x 10 mm at a defined speed. If not otherwise specified, after pre-treating the sample surface for 1 sec, a forward movement of 1 mm took place. During pre-treatment the plasma-pen was mounted at a right angle to the moving sample and was kept at an operating distance of 3 mm.

Figure 1 shows the prototype of the plasma-pen. The pen works under atmospheric pressure and produces a plasma jet with a sphere of action in the millimetre-range. The instrumental setup for operating the plasma is schematically depicted in figure 2.

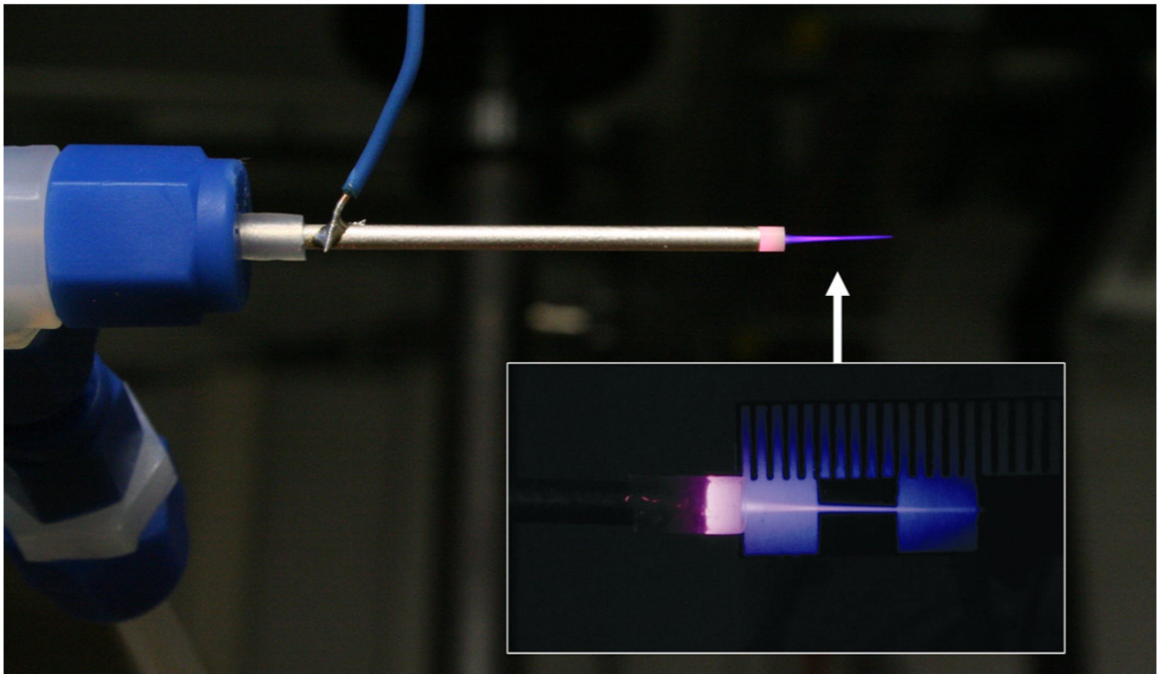
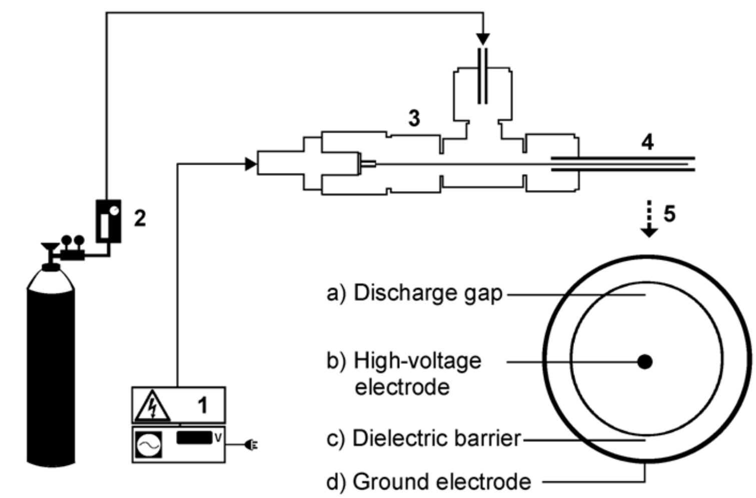


Fig. 1. Photograph of the plasma-pen by displaying the plasma jet under magnification.
One mark on the scale corresponds to 1 mm. (Photograph by the author)



1. AC-Power supply coupled to a high voltage transformer
2. Process gas supply pipe with gas flow control unit
3. Plasma source
4. Capillary
5. Cross-section through the capillary

Fig. 2. Instrumental setup for operating the plasma-pen

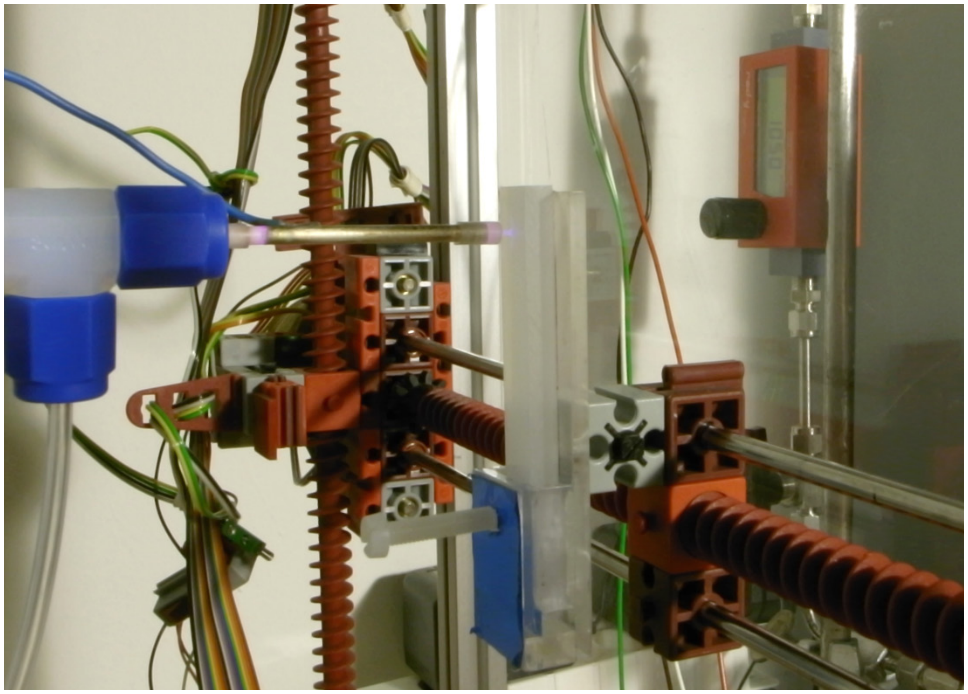


Fig. 3. Sample pre-treatment using a computer-controlled, step-motor driven x-y plotter (Photograph by the author)

3. EVALUATION OF IMPROVEMENTS IN BONDABILITY

The effectiveness of the plasma pre-treatment for enhancing the bondability of low-density polyethylene (PE-LD), high-density polyethylene (PE-HD) and PP has been proven by testing the tensile shear strength of untreated and plasma pre-treated adhesive bonds. Tensile shear tests were performed on commercially-extruded polymers, cut into small plates measuring 70 x 10 x 5 mm and cleaned with propan-2-one. For sample preparation, the polymer plates were positioned so they overlapped by 10 mm and then bonded with the acrylic resin Paraloid B-72. The resin was solubilised in toluene (1:1 parts by weight) and applied with a film-drawing device (wet film thickness: 100 µm). After the adhesive had dried completely (PE-LD: 8 weeks, PE-HD/PP: 6 weeks) under constant pressure (267 g/cm^2) the extent of adhesion improvement was quantified using the tensile testing equipment[3] shown in figure 4. The adhesive bonds were pulled until failure (testing speed 50 mm/min) and the adhesion improvement was quantified by comparing the breaking strength of untreated and plasma-treated samples. For each test series at least nine identically treated samples were tested. Measured data were evaluated statistically, like all results in this study, on the basis of calculated averages and standard deviations, and they are displayed in figures 4-6 with confidence intervals of 95%.

4. EVALUATION OF IMPROVEMENTS IN COATABILITY

With regard to evaluating the effectiveness of the plasma pre-treatment for enhancing the adhesion of retouchings, improvements in coatability were examined in pull-off tests, carried out on gouache-painted PE-HD and PS.

Extruded polymer plates (PE-HD: 70 x 10 x 5 mm, PS: 70 x 10 x 4 mm) were coated with gouache paint (wet film thickness: 50 µm), again by using the film-drawing device.

Coatings dried in controlled climate conditions (RH 50% +/- 5; 23°C +/- 3). Metal stubs, 5 mm in diameter, were adhered to the dried coatings using a highly viscous cyanoacrylate adhesive. This low-penetrating adhesive was chosen in an effort to minimize its effects on the test results, and was chosen based on the results of preliminary testing.[4] 24 hours after the metal stub application, the force required to pull off the coatings was measured with the tensile tester (fig. 5a). The adhesion improvement was quantified by comparing the pull-off strength of untreated and plasma-treated samples. For each of the test series, at least eight identically treated samples were tested and results were evaluated statistically as described above. PE-HD samples were tested four weeks after gouache paint application. Coatings on PS had to be tested after 1 week, because on the untreated PS surfaces, gouache coatings lifted-off the polymer support by themselves if stored for any longer than this period of time (fig. 5b).

5. EXPERIMENTAL RESULTS CONCERNING THE PRE-TREATMENT'S EFFECTIVENESS

As can be seen in figure 4, the adhesive qualities of PE-LD, PE-HD and PP were noticeably improved after plasma pre-treatment. The tensile stress necessary to separate all adhesive joints showed a marked increase. The breaking force necessary to separate the PE-LD adhesive bonds showed a significant increase from 26 ±19 N/cm^2 to 160 ±38 N/cm^2. In the case of PE-HD, a significant augmentation from 31 ± 11 N/cm^2 to 215 ± 44 N/cm^2 took place. On PP an improvement of the breaking force from 30 ± 23 N/cm^2 to 112 ± 32 N/cm^2 was obtained. Besides this significant improvement of bondability, the applied gouache coatings also gained a considerable mechanical resilience after plasma pre-treatment (fig. 5). Without pre-treatment a very low tensile stress was enough to cause adhesive failure and pull off the coatings (PE-HD: 10 ± 7 N, PS: 1 ± 3 N). In contrast, on the plasma-treated surfaces, all applied gouache coatings gained a considerable mechanical resilience (PE-HD: 114 ± 34 N, PS: 78 ± 30 N). The plasma pre-treated samples mostly showed cohesive failure inside the gouache layer itself.

6. EXAMINATION OF CHANGES IN SURFACE POLARITY AND OXIDATION STABILITY

Plasma pre-treatment initiates chemical changes in polymer surfaces. This becomes obvious if a drop of water is placed on a pre-treated non-polar plastic surface, as it displays a marked improvement in water wettability. The improvement in wettability of PP was quantified by water contact angle measurements, as shown in figure 6.[5]

The observed change of hydrophilicity is caused by an enhancement of the polymer's surface polarity, as analysed with infrared spectroscopy in attenuated total reflection (ATR-IR). The comparison of ATR-IR spectra taken from an untreated and a plasma-treated PP surface revealed a considerable increase of polar, oxygen-containing functional groups after pre-treatment (fig. 7). The most notable changes were found in the IR-absorbance range at about 1850-1550 cm^{-1}, known to be the absorbance region of carbonyl stretch vibrations.[6]

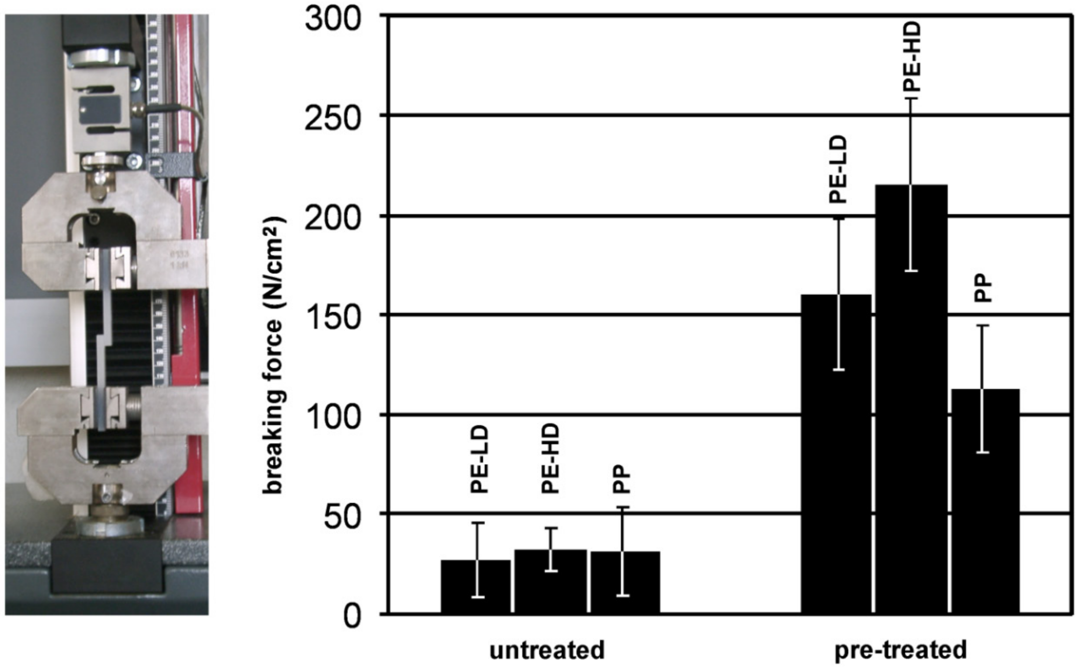


Fig. 4. Effect of the pre-treatment on the bondability of PE-LD, PE-HD und PP (Photograph by the author)

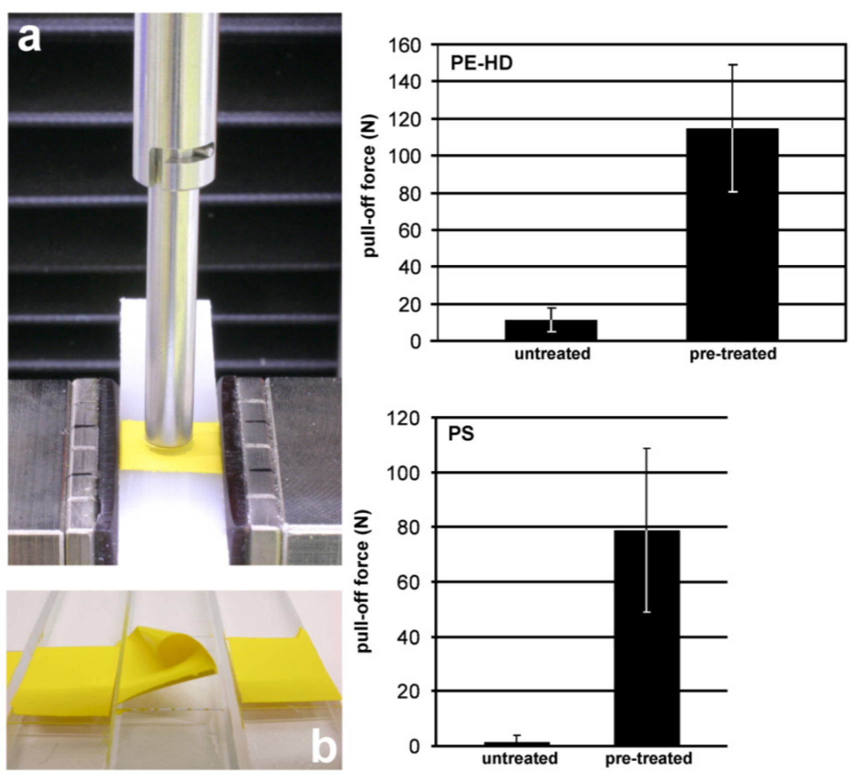


Fig. 5. Effect of the pre-treatment on the coatability of PE-HD and PS. Upper graph: measured pull-off forces on PE-HD; Lower graph: measured pull-off forces on PS. Pre-treatment time: 0.5 s/mm; a: experimental set up for pull-off testing; b: lifted-off gouache coatings on untreated PS. (Photographs by the author)

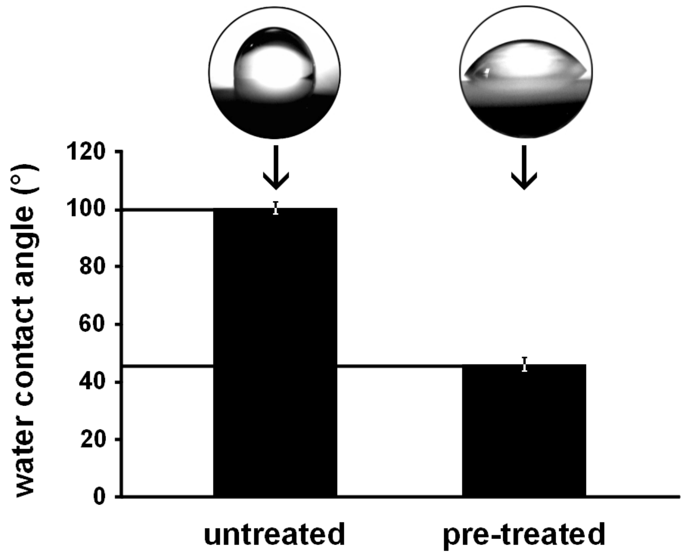


Fig. 6. Effect of the plasma pre-treatment on the surface wettability: advancing water contact angles on untreated and pre-treated PP surfaces, measured on PP polymer films (270 μm). For each test series, 14 measurements were performed by using a contact angle goniometer.

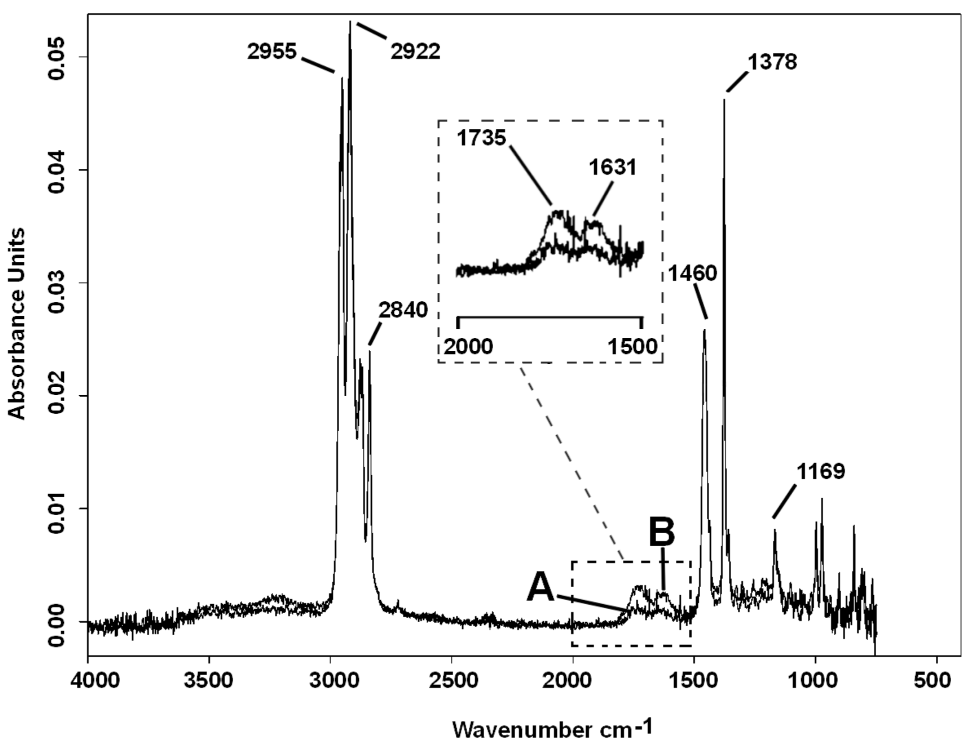


Fig. 7. Effect of the plasma pre-treatment on the surface polarity: FTIR-ATR spectra taken from an untreated (A) and a plasma pre-treated (B) PP surface. Most notable changes, found in the IR-absorbance range of carbonyl stretch vibrations, are displayed under magnification.

The detected carbonyl compounds are well-known reaction products of polymer oxidation (Sheirs 2000, 416). Their increase indicates that an essential mechanism during plasma pre-treatment is radical-initiated surface-oxidation. Because little is known about whether or not this surface oxidation negatively affects the oxidation stability of the pre-treated materials, an analytical long-term observation of the oxidation stability of plasma-treated polymers has been started. Untreated and plasma pre-treated polymer samples are stored in the dark under museum climate conditions. In the future they will be periodically checked with regard to changes in oxidation stability. Oxidation behaviour of the samples is monitored by performing chemiluminescence analysis (CL), a very sensitive analytical technique for testing the oxidative stability of organic polymers. This analytical method depends on the fact that organic polymers emit light during oxidation processes. The emitted light, too weak to be visible to the naked eye, can be detected using light-sensitive analytical equipment (Käser et al. 2007). Characteristic changes in the light emission of the samples can be used as an indicator of changes in their oxidation stability (Jacobson et al. 2004). To date, CL measurements have been performed on additive-free PE-LD films before and directly after plasma pre-treatment, as well as on plasma pre-treated samples that have been stored for five months in the dark. There is no indication that plasma pre-treatment negatively affects the oxidation stability, at least over this period of time. All plasma pre-treated samples showed no differences in light emission in comparison to untreated samples.[7]

7. CONCLUSION

In order to overcome adhesion problems during conservation treatments on non-polar plastics, the plasma-pen seems to be a promising tool. On PE, PP and PS surfaces the plasma pre-treatment resulted in a significant improvement of adhesive qualities. The breaking forces necessary to separate all plasma pre-treated adhesive bonds were significantly increased. Furthermore water-based gouache coatings gained a considerable mechanical resilience. It is expected that adhesion of other polar adhesives and coatings than those tested here can also be elevated, provided that their dried films have an adequate cohesive strength. This has interesting implications for conservation practice: plasma pre-treatment allows bonding and retouchings with high mechanical resilience on non-polar plastics, thereby prolonging the expected lifespan of conservation measures. Besides the observed improvement of bondability and coatability, it is notable that after plasma pre-treatment the application of mechanically resilient, water-based and water-removable gouache retouchings on hydrophobic plastic surfaces became feasible. Especially on the water-insensitive but otherwise solvent-susceptible plastic PS, the application of water-based and water-removable retouching is a very interesting way to attain reversibility. Last but not least, it is very important to know as much as possible about whether or not plasma-treatment negatively affects long-term oxidation stability of the pre-treated materials. The long-term monitoring of oxidation stability will continue and future CL-measurements will expand the knowledge about this issue.

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NOTES

1. Unless diffusion processes are involved. Bonds gained via diffusion processes (e.g. during welding or solvent bonding) are expected to be irreversible. Furthermore, applied on thermoplastics, diffusion processes are associated with the risk of heat or solvent damage (e.g. stress crazing).

2. All sample pre-treatments were performed with a voltage input at about 1600 V and helium (with admixture of 0.5% oxygen) was used as operating gas.

3. Tensile testing equipment: Zwick 1120, Zwick GmbH & Co. KG, Ulm, Germany.

4. To examine the penetration behavior of the cyanoacrylate adhesive, the adhesive was left to dry on carrier-free gouache films (wet film thickness: 50 μm) and the chemical composition of the opposite sides of the gouache films were analyzed with infrared spectrometry in attenuated total reflection (ATR-FTIR). The gouache films showed no accordant IR-absorbencies on the sides opposite the adhesive.

5. Contact angle measurements were performed directly after plasma pre-treatment. During each measurement a drop of deionized water with a volume of 5 μl was placed on the polymer surface and a second drop of 5 μl was centered on the first. The advancing contact angles were determined within 60 seconds after the first contact of the liquid with the surface.

6. Infrared spectra were obtained six hours after plasma pre-treatment using a Fourier transform infrared spectrometer Vertex 70 from Bruker (2 cm^{-1} resolution, 64 scans). For semi-quantitative evaluation, peak intensities were normalized by adjusting the intensity of the symmetric CH_2-stretch vibrations (2922 cm^{-1}) according to Morent et al. 2008.

7. Chemiluminescence data were obtained using an apparatus developed by Käser et al. 2006. Measurements were performed for each test series in triplicate using the same pre-treatment, storage and measurement conditions (measurement gas: oxygen 60 mL/min, non-isothermal experiment from 35-110°C, heating rate: 0.2°C / min).

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SOURCES OF MATERIALS

Gouache paint (cadmium yellow, PY 35)
H. Schmincke & Co.-GmbH & Co. KG
Erkrath, Germany

Paraloid B-72
Lascaux Colours & Restauro
Brüttisellen, Switzerland

PE-HD and PP samples for tensile testing
Cellpack AG
Villmergen, Switzerland

PE-LD samples for tensile testing
SIMONA AG
Kirn, Germany

PP homopolymer film (270 µm), additive-free PE-LD film (230µm)
Goodfellow Research Materials GmbH
Bad Nauheim, Germany

PS samples for tensile testing
Novoglas AG
Villmergen, Switzerland

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KISS AND TELL: THE CONSERVATION OF LIPSTICK-BASED WORK BY RACHEL LACHOWICZ

ELIZABETH HOMBERGER AND CARL PATTERSON

ABSTRACT

This paper seeks to further the study of the conservation of contemporary art composed of non-traditional art materials through a discussion of the treatment of two lipstick-based sculptural works by the artist Rachel Lachowicz. The reinstallation of *One Month Late* and *Untitled (Lipstick Urinals)* afforded conservators at the Denver Art Museum the opportunity to develop a holistic approach to the preservation and installation of the works. This approach included collaborating with the artist to document her techniques and intent, as well as materials analysis and research to understand the deterioration processes of lipstick. Examination of the works revealed similar condition issues including "sweating" and mechanical damage. The composition and deterioration of lipstick are discussed, as are the treatment and preventive conservation plans for the lipstick-coated urinals and ties.

1. INTRODUCTION

Rachel Lachowicz is a Los Angeles-based artist perhaps best known for her use of cosmetics to re-contextualize iconic works by male artists, such as Carl Andre's tiles, Donald Judd's boxes, and Marcel Duchamp's and Robert Gober's urinals. The Denver Art Museum (DAM) has in its collection two lipstick-coated works by the artist that were recently installed in their galleries. A third work in the collection titled *Birthday Card* was not included in the exhibition, but was fabricated using similar materials. This group of works provides a useful and interesting case study for addressing the primary issues in conserving and preserving what could be considered ephemeral art. To understand the works better, research into materials, construction, and artistic intent was carried out. Conversations with the artist proved essential in preparing the works for installation and, it is hoped, gaining years of useful exhibition life.

2. BACKGROUND: DESCRIPTION OF WORKS

One Month Late, *Untitled (Lipstick Urinals)* and *Birthday Card* are examples of Rachel Lachowicz's work from the 1990s. They represent the artist's early experiments in applying lipstick to recognizable substrates. Realizing the full cultural significance associated with lipstick, Lachowicz's recast or altered objects are both deconstructions and parodic appropriations that act to assert her "feminine/feminist presence" (Marino 1995). The artist's manipulation of lipstick and other cosmetics within the art historical context operates on many levels. It can be described as an acknowledgement of gender roles and stereotypes as well as the desire to beautify and, in some cases, express her admiration of the male artists from whom she appropriates.

After almost 20 years in the museum's collection, condition changes had become obvious in both pieces. The lipstick-coated works exhibited "sweating" on all surfaces, dust accumulation, cracks, and other challenges associated with conserving contemporary art created with non-traditional materials. When originally made the surfaces were smooth and silky, much like those of recently cooled candle wax. Soiling, oily material migration and minor surface damages altered this.

Fig. 1. Detail of sweating with trapped dust (Denver Art Museum, 1992.548) (Photograph by Liz Homberger)

Fig. 2. Rachel Lachowicz, *One Month Late*, 1992, lipstick, wax, ties, resin, high heels, metal hanger, dimensions variable, Denver Art Museum (1992.548) as installed in 2002 (Photograph by Jeff Wells)

2.1 DESCRIPTION OF *ONE MONTH LATE*

One Month Late is an installation piece composed of neckties, a metal hanger and a pair of hot pink high-heeled shoes—all coated with layers of bright red lipstick. The ties are actual fabric neckties of varying lengths and widths, coated with resin and then lipstick. The hanger and shoes were not treated with resin before coating with lipstick. When installed, the ties and hanger are suspended from the ceiling with monofilament and the shoes are placed on the floor below the hanger. The ties are hung at natural heights, as if worn, to represent a realistic group of men. The shoes are situated below the hanger in a position evocative of a woman whose body is demarcated by the suspended hanger. The artist describes the relationship between the components as fundamental to the piece, but their precise positioning is dependent upon the space in which the work is installed. “The dimensions are variable and the work is site-specific. So, whatever looks good in the space should be done. I’d hate to give more detailed plans and then have the installation not fit or work in the space…the work is meant to feel like you’re in a surrealist painting” (Lachowicz 2008).

2.2 DESCRIPTION OF *UNTITLED (LIPSTICK URINALS)*

Untitled (Lipstick Urinals) is a work composed of three Hydrocal plaster casts of small plastic urinals that have been coated with a mixture of lipstick and wax. The artist made several editions of the work; another set is in the collection of the Los Angeles County Museum of Art. Each urinal measures approximately 15 x 8 x 5 inches, although the overall measurements vary with each installation. The installation of this piece is straightforward: the three urinals are hung side by side on a wall with mounting cleats. In the first installation (at the Shoshana Wayne Gallery) Lachowicz installed the urinals at “child height.” However, in recent discussions with the artist, she altered her instructions so that the height and distance between the urinals be adjusted according to the installation site, so that the piece “fits” the space.

2.3 DESCRIPTION OF *BIRTHDAY CARD*

The third piece by Lachowicz is titled *Birthday Card*. The work is a rectangular paper support coated with a mixture of lipstick and wax. The surface is heavily textured from the application of multiple layers of the lipstick mixture. The coating extends off the bottom edge in uneven drips.

3. LIPSTICK

Before continuing with a discussion of the condition of the works, it is worth discussing the composition and properties of lipstick. Over the course of its 5,000 year history, lip colorants have included henna, fucus, cinnabar, and carmine dye (made from cochineal). As a commercial product, lipstick was first available in the US in 1915. By 1925 the product had changed significantly to incorporate dyes that enhanced its indelibility. Since then, the basic formula hasn’t changed greatly. When there is change, it is driven by fashion.

Fig. 3. Rachel Lachowicz, Untitled (Lipstick Urinals),1992, lipstick, wax and plaster, dimensions variable, Denver Art Museum (2001.772.1-3), installed in 2002 (Photograph by Jeff Wells)

Fig. 4. Rachel Lachowicz, *Birthday Card*, 1992, lipstick, wax and paper, 11.5 x 8.5 inches, Denver Art Museum (1992.659) (Photograph by David Turnbull)

3.1 COMPOSITION OF LIPSTICK

The expectations of lipstick are great: it should produce the desired color and effect; be long lasting, moisturizing, nearly indelible; remain a solid in a range of conditions; cover evenly; and be non-toxic. As an art medium, it is the cultural significance that is most appealing. Lipsticks can be complex combinations of 20 or more ingredients. Although the composition of modern lipstick varies from product to product, the main components responsible for its basic properties are oils, waxes, and colorants. The percentages in which these are added have been reported as ranging from: 15-25% wax, 65-80% oil, and 5-10% pigment (Matsuda et al. 2001). Other additives include fillers (~10%), emollients (~25%), and perfumes (<1%).

Oils give lipstick its shine and easy application quality, and include olive, silicone, mineral, and castor oils. Animal, vegetable and hydrocarbon waxes, including beeswax, carnauba, candelilla, and paraffin, contribute to the crystalline structure of the stick as well as its "staying power" and texture. Often other fatty materials are present, such as cocoa butter, lanolin and other esters. These materials are the link between the waxes and oils and play a role in the creaminess and hold of the film (Salvador and Chisvert 2007).

The vivid colors of lipsticks are created with the addition of pigments, lakes or dyes, including iron oxides and bromofluorescein (bromo acids). Color is imparted either by staining or covering. In some cases the color reaches its final form when applied to the lips as the dye chemically reacts with amino acids in skin. Titanium dioxide is often added for its superior covering power and also to produce pink hues. Bromo acid dyes are the most common staining colorants; two frequently used bromo acid dyes are 4', 5'-dibromofluorescene and 2', 4', 5', 7'-tetrabromofluorescein (also known as eosin, D&C 21). The lightfastness of these colorants varies greatly: the iron oxides have excellent stability while some lakes and many of the bromo acids exhibit poor lightfastness. Generally, lipsticks contain a mixture of colorants.

In terms of processing, aside from the ingredients, temperature manipulation is key to producing a stable stick. The basic steps of manufacture include pre-wetting the pigments in oil; passing the dispersion through a mill; heating the oil and wax to just slightly above the melting point of the highest melting point wax; cooling the mixture slightly; adding colorants while stirring; filling molds at a slightly cooler temperature (approximately 70˚C); and finally, flaming of the tube (Finkenaur 2000).

The composition and overall manufacture of a tube of lipstick is the result of extensive research. As much as the aforementioned materials are necessary to achieve the desired color, texture, melting point and film flow, their interaction with one another and with the environment can also hasten the deterioration of the product. The most common types of deterioration are described below.

3.2 DETERIORATION OF LIPSTICK

In a review of scientific literature, it was found that the most frequently cited problems in the deterioration of lipsticks are the oxidation of oils and "sweating." Extensive research has been carried out by the cosmetics industry to better understand the causes of these issues.

Many of the oils used in lipstick are susceptible to oxidative cross-linking, chain scission, and yellowing through the incorporation of oxygen (Mills and White 2003). In cosmetics, oxidation can result in a number of undesirable changes including fading or color shift, rancidity, and brittleness. Antioxidants such as propyl gallate are added to inhibit or slow the oxidation of fats, oils and perfumes in lipstick. One post-manufacture solution to oxidation is improved packaging: airtight containers with multiple seals can slow the process and also reduce water vapor loss in water-based cosmetics.

Sweating can be defined as the migration of liquid, in the form of droplets, to the surface of a mixture. The phenomenon is caused by solid-liquid separation. Droplets produced under experimental conditions have been found to be composed of oils and esters of waxes. The loss of these components can lead to brittleness and poor spreadability. Although the exact mechanism of sweating in lipstick is unknown, studies have described the factors influencing the phenomenon to include: ageing, temperatures above 20˚C (68˚F), relative humidity above 55%, the presence of hygroscopic organic pigments in the lipstick, pigment load, compatibility of the oil and wax (i.e. the coefficients of expansion and solubility parameters), and the density of the wax matrix (Matsuda et al. 2001; Salvador and Chisvert 2007). The ratio of oil to wax is frequently cited as a factor, and in simple terms, there seems to be less sweating when more wax is present.

One proposed mechanism describes the difference in the coefficients of expansion between waxes and oils and this relationship to temperature. Briefly, with increased temperature the less stable components—oils generally—expand to a greater degree than the wax and migrate to the surface through channels in the matrix. A study of simplified oil and wax systems found the phenomenon to be temperature dependent: by holding RH constant and manipulating temperature, sweating was observed beginning at 20˚C and as the temperature increased, so did the size and number of droplets (Matsuda et al. 2001). Other studies have described the compression effect of extrinsic water on oil by moisture sorption with increased temperature and RH.

In short, temperature and relative humidity are the most significant post-manufacture factors contributing to the sweating of lipsticks. Industry's recommendations for the prevention or reduction of sweating include the use of inorganic pigments, the inclusion of gelling agents and, post-manufacture, the maintenance of temperatures below 20˚C and RH below 55%.

4. CONDITION

Considering the potential vulnerability of lipstick, both *One Month Late* and *Untitled (Lipstick Urinals)* were found to be in fair condition. *Birthday Card*, on the other hand, exhibited cracking of the lipstick coating. The fragrance, an important part of the experience of the works, was still readily apparent. The main condition issue exhibited by all three works was the sweating of coated surfaces, which resulted in a highly glossy surface, speckled with pale yellow droplets and trapped dust. The other major issue was the presence of handling marks, presumably from incidences when visitors touched the work during previous installations. The lipstick coating itself was found to be fairly solid with the exception of areas of mechanical damage or where the greasy material had migrated to the surface. A comparison of the present condition to earlier reports indicated that this was not newly occurring, but was more extensive. This points to the exacerbation of the sweating by storage in sealed containers.

Fig. 5. Glossy surface on tie (Denver Art Museum, 1992.548AD) (Photograph by Liz Homberger)

Fig. 6. Detail of surface including areas of "sweat", dust and handling marks (Denver Art Museum, 1992.548S) (Photograph by Liz Homberger)

4.1 CONDITION OF *ONE MONTH LATE*

In addition to the issue of sweating, many of the ties were found to have highly glossy areas where the lipstick and migrated material had been in direct contact with Mylar used in the housing of the objects. Out of the 32 components, 53% were found to have moderate to extensive areas of droplets and glossiness. Sweating appeared to be random in location. A significant amount of dust had become trapped in the residue. Additionally, several of the ties exhibited small cracks in the lipstick coating and scratches from handling.

4.2 CONDITION OF *LIPSTICK URINALS*

The urinals were found to be in excellent structural condition, despite extensive sweating and minor marks from handling. For the most part, the handling marks were fingerprints and streaks that appeared to be mostly present in the greasy layer atop the lipstick (Fig. 7). Additionally, a moderate amount of dust had accumulated on the top surfaces of the urinals during previous exhibitions.

Fig. 7. Sweating with streaks (Denver Art Museum, 2001.772.1) (Photograph by Liz Homberger)

4.3 CONDITION OF *BIRTHDAY CARD*

Although *Birthday Card* was not selected for installation, brief examination revealed extensive sweating and cracking. The cracks are probably the result of inherent vice: the use of a flexible substrate for the heavy, stiff lipstick coating.

5. RESEARCH

As noted in previous papers and presentations on the conservation of contemporary art, it is often critical to the preservation of a work that there be a relationship or collaboration between artist and museum (Coddington 1998; Sloggett 1998; Foundation for the Conservation of Modern Art 1999). It is important to remember that "the meaning of the work prior to conservation is the foundation for responsible decision making in the conservation of modern art" (The Foundation for Conservation of Modern Art 1999, 167). In the case of this project, determination of the meaning and understanding of the work was achieved through analysis, research into lipstick, and discussions with the artist.

5.1 ANALYSIS

Analysis of both the coating and sweat droplets was carried out in order to understand the sweating phenomenon. Fourier-Transform Infrared Spectroscopy (FTIR) and non-destructive x-ray fluorescence (XRF) spectroscopy were performed to characterize the coating and the droplets.

5.1.1 Analysis of the Coating

Non-destructive analysis of the lipstick coating was carried out using a Bruker AXS TRACeR III-V handheld XRF unit. XRF analysis was carried out with the goal of detecting inorganic elements that may have been used as colorants. Of note is the presence of bromine in the coating (Fig. 8), which may indicate the use of a bromo acid dye as colorant. Such dyes are common ingredients in lipsticks as they provide good staying power by staining the lips.

A small sample of the coating from *Birthday Card* was collected and analyzed using FTIR. The sample was placed onto a sodium chloride window for analysis in transmission mode using a SpectraTech IRPlan FTIR microscope attached to a Mattson Polaris FTIR spectrometer. The spectrum for the coating was found to match closely to the reference spectrum for a high-melting-point wax identified as "Concord Wax" (Fig. 9). Of note in the spectra are the peaks around 1700 cm^{-1}; these carbonyl absorptions are probably from esters and carboxylic acids in the wax. Considering the presence of the carbonyl vibrations, it seems likely that the wax is something like a carnauba wax, which contains esters, and not a refined hydrocarbon wax. Of course, the coating is known to be a mixture, so the presence of other waxes and materials cannot be ruled out. It should be noted that while FTIR gives molecular structural information and can be used to distinguish between mineral waxes and the more complicated spectra of plant and animal waxes, it cannot be used to identify specific waxes because of the similarity of their chemical structures. Other techniques such as gas chromatography mass spectroscopy (GC-MS) would provide more complete chemical identification of the material (White 1978). Unfortunately, due to time and budget limitations this was not within the scope of the project.

Although further analysis was not possible, it would also be worthwhile to confirm the presence of a bromo acid dye and other colorants in the coating. This would allow for a better understanding of the sensitivity of the coating to light. Also important would be to fully characterize the composition of the lipstick coating for each of the three works; having a better idea of specific waxes used as well as the proportion and compatibility of oils and waxes could further the understanding of the sweating mechanism.

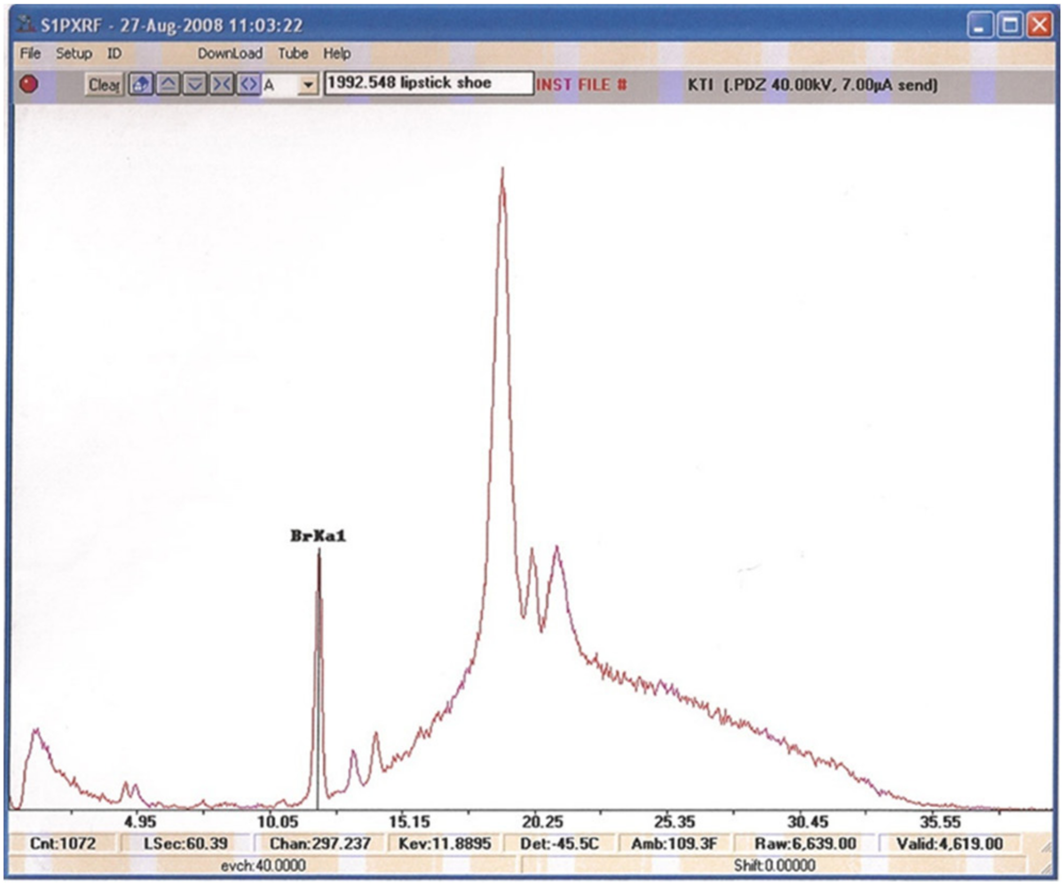

Fig. 8. XRF spectrum of coating

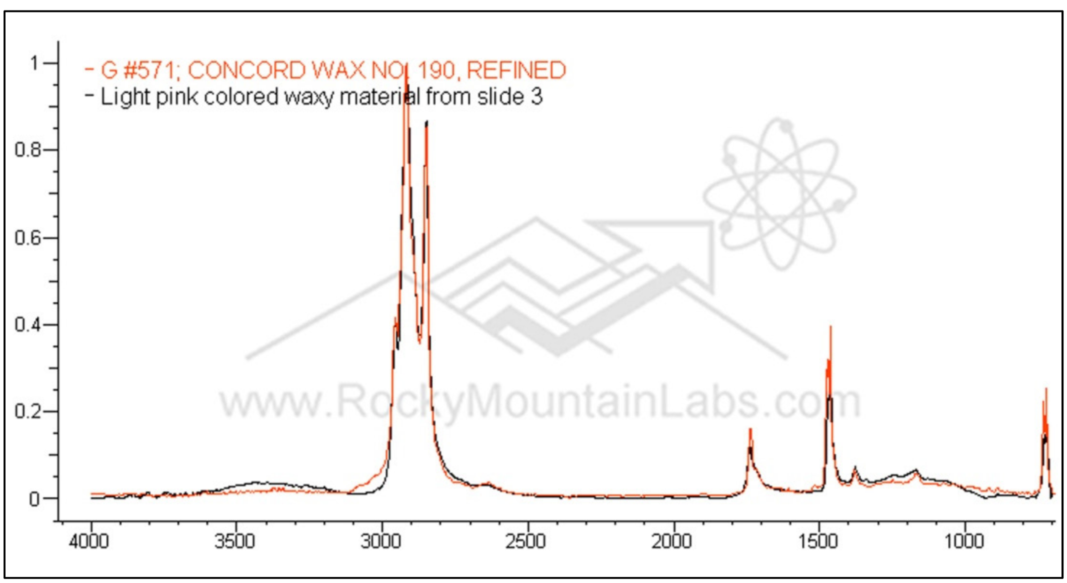

Fig. 9. FTIR spectra of coating and reference match

5.1.2 Analysis of Sweat Droplets

Samples of "sweat" were analyzed by Rocky Mountain Laboratories, Inc. using FTIR. Samples were placed onto a sodium chloride window for analysis in transmission mode using a SpectraTech IRPlan FTIR microscope attached to a Mattson Polaris FTIR spectrometer. The resulting spectrum was found to be a close match to a reference spectrum for lanolin (Fig. 10).

Lanolin, also called "wool grease," is a semi-solid, waxy material produced by the sebaceous glands of sheep. Extracted from wool and refined, lanolin and its derivatives, such as cholesterol/lanosterol and lanolin oil, are commonly used as ingredients in cosmetics (Finkenauer 2000). In the past lanolin has been used in the conservation field as a leather dressing and as a coating to prevent corrosion of iron alloys. Although its structure and composition have not been fully characterized, lanolin is a complex mixture of esters of fatty acids and high molecular weight alcohols. One notable property of the material is that its melting point is significantly lower than that of other waxes, ranging from 36-43ºC. Another important characteristic is that lanolin readily forms emulsions with water.

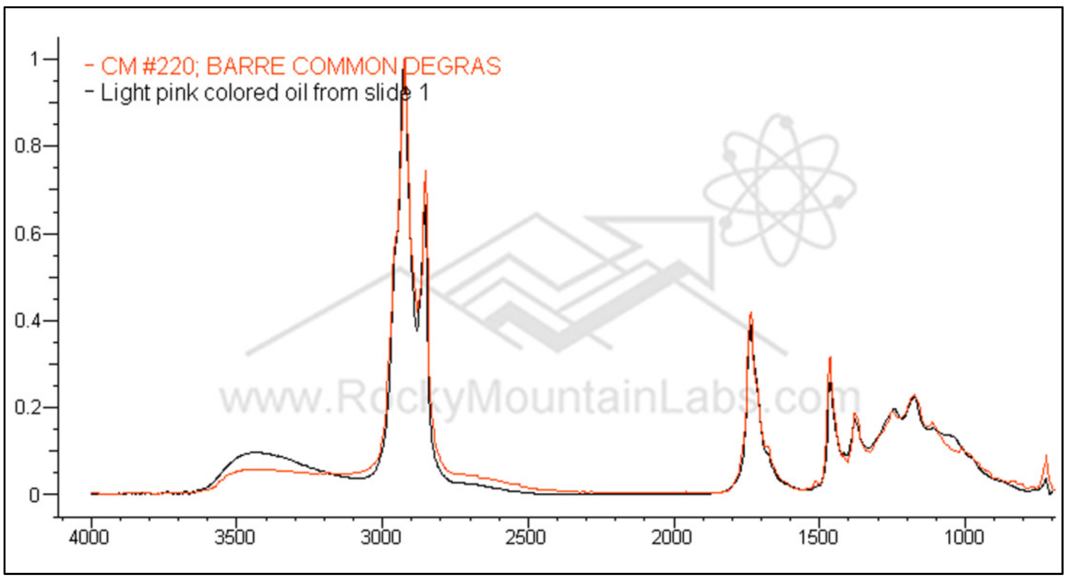

Fig. 10. FTIR spectrum of sweat droplets

5.2 COMMUNICATION WITH THE ARTIST

Several informal conversations with Lachowicz were carried out by telephone in order to understand the artist's thoughts about specific condition issues as well as the construction of the works and their meaning. A recorded interview was conducted during a visit to the artist's studio as a part of the Denver Art Museum's project to document artists' techniques and positions about conservation. Specific questions about technique and preservation were asked in order to gain greater perspective about the "lifetime" of the works. A second interview was carried out by assistant conservator David Turnbull when the artist visited the museum.

5.2.1 Meaning, Materials and Fabrication

The materials Lachowicz selected have paramount significance to the meaning of the works. This is perhaps even more relevant in the case of the urinals than with *One Month Late* because the lipstick is covering/altering an object that can be described as emblematic of masculinity. A material with stronger associations to Western ideals of femininity and beauty is hard to find, and in Lachowicz's words, lipstick is "indexical of women." In this sense, it is not just the material itself that is important, it is the concept and that the material indexes a changing standard of beauty. Any imperfections in the coating would detract from the richness of the experience as well as the appreciation of the message. When asked specifically if the oily droplets and residue should be removed from the surface, Lachowicz remarked: "Yes…especially because there's usually dirt associated with the sweating." In the past she has washed her works to remove the oil and grime, stating "I want the work to look good, not to communicate 'this gets damaged over time,' or 'boy this looks like a mess' " (Lachowicz 2008). Lachowicz noted that she has seen sweating in many of her lipstick pieces, but particularly in those that have been stored in sealed containers. Also of note is that lipstick is so much a part of the artist's practice that it has been recognized as a signature (Porges 2006).

Lachowicz described the purity of materials (or the fact that in *One Month Late* real ties, high heels and hanger were used instead of fabricated objects) as being important to the meaning when she first made them. She has always used the same source for the lipstick—a small company in Los Angeles—from which she orders the lipstick "greasy" (i.e. without much wax) and has always modified it with a low melting point, artist-grade wax. The wax is added until the lipstick is more durable and workable, and also to give the nuanced appearance she wants. Lachowicz has remarked that although she varies the amount of wax in order to achieve the workability and appearance she wants, she has at times bulked the lipstick with "as much wax as possible before it is technically a candle."

In terms of their fabrication, the components of the three works were repeatedly dipped in the molten lipstick/wax mixture so that they are coated with multiple layers of lipstick. The process of combining the wax and lipstick is time consuming and must be carried out at low temperatures over the course of hours so that the mixture does not separate or burn. The artist has never recorded the exact temperature of melting because she relies on the physical characteristics, such as the flow of the material. This information would be important to collect since the temperature of heating and pouring is known to influence the stability of the final product.

In *One Month Late* the ties were first tied and hung from tubes and then brush-coated with polyester resin in order to make them rigid and to maintain their form as if worn; after coating, the resin was sanded with increasingly fine grits of sandpaper. Small holes were then made in the back of the knots of the ties and eyehooks were screwed directly in to provide a method for hanging. The urinals were cast in plaster directly from plastic urinals purchased by the artist. After casting, the urinals were dipped in large vats of the molten lipstick mixture, allowed to cool, and then sanded with increasingly fine grits of sandpaper. The overall effect of this labor-intensive process was a smooth, pristine surface.

5.3 DISCUSSION OF RESEARCH

Analysis and communication with the artist provided interesting information to consider in relation to the sweating observed in both works. The possible presence of lanolin, a complex mixture of fatty acids, alcohols and free fatty acids, is compatible with the findings of the fatty acid esters in the cosmetic industry's research summarized earlier in this paper. It is possible that the sweating is the result of intrinsic incompatibilities between the materials in the mixture, as well as the closed storage of the works and subsequent establishment of a microclimate. It is also possible that the reheating and/or pouring of the mixture at too high a temperature caused separation of the phases and subsequent sweating in unfavorable storage conditions.

The deterioration mechanisms of complex mixtures like lipstick are not easily understood. However, additional research into the composition of the mixture may further the understanding of the sweating phenomenon.

6. CHANGING PERSPECTIVES

Contemporary art, particularly installation art, is dynamic. Its orientation and meaning can change with each re-installation. This dynamism can mirror the artist's shifting perspective over time. In the case of these works, discussions with the artist proved to be insightful and truly informed the entire process of preparing the work for installation, but also revealed a change in the artist's intent.

6.1 ARTIST'S PERSPECTIVE

The artist's own feelings toward preservation and even the conceptual focus [of *One Month Late*] have changed since the works were made over 15 years ago. Lachowicz recently explained that: "The medium is the message. In the early days that meant absolute purity, and I think now what it means is taking care that the message is not damage." She expressed interest in protecting the work from environmental damage and handling through the use of vitrines or bonnets, admitting that she would not have wanted the work displayed in this manner when she first made it as it may have interfered with the viewer's interaction with the work. Lachowicz was also interested in being true to the material's natural ageing process provided that the changes were reasonable in this context, and not the result of neglect or disregard. Overall, she considered ageing as part of the "history of the piece"—a factor that was important to understand.

In the case of *One Month Late*, the artist originally intended the work to be politically and emotionally charged. The provocative, conceptual nature of the piece was of great importance initially, however, Lachowicz recently expressed an interest in softening the tone and making it more ambiguous (i.e. less literal) by removing the hanger. The interest now is more on the aesthetic nature of the piece and the symbolic relationship between the women's heels and the men's ties. In spite of the artist's desire to dilute the subject matter, the curator was interested in the historic/evidentiary value of the work, in other words, the work as it was originally intended. Lachowicz understood of the importance of the installation as representative of her early work.

7. TREATMENT

The information collected over the course of researching the works played a key role in the determination of the steps and goals of the treatment. Without the artist's collaboration, the treatment may have proceeded differently to include only the removal of dust, as in the case of the initial installation at the DAM in 2002. The artist described her own interventions as having included remaking or recoating works. She also described re-melting areas of minor damage. In an example of her interest and involvement with pieces in other collections, Lachowicz described remaking a work that had been damaged by a visitor; in fact, she made two pieces, the exhibition copy was installed under a Plexiglas bonnet and the other was kept in storage. She also worked with the museum to alter the housing system to allow for air circulation during storage.

7.1 TREATMENT STEPS

In the case of the works in the collection of the Denver Art Museum, the treatments were nearly identical. It should be noted that the treatments were exhibition-driven, so only the two works selected for exhibition were treated. Treatment was aimed at removing the significant layer of dust accumulated on the surface of the works and reducing areas of sweating and glossiness. Groomstick (a non-vulcanized isoprene material) was found to be the only material that would remove the dust trapped in the oily surface, and it had the added benefit of picking up some of the sweat, thereby reducing the overall glossiness of the piece. A second step was carried out to further reduce the oily residue on the surface: small sheets of acid-free tissue were applied to the surface in a gentle blotting motion. Areas of glossy, burnished residue on the ties were made matte by blotting with Groomstick. Wherever possible, handling marks were minimized by mechanical means. It was found that the fingerprints and streaks on the urinals were largely present in the oily layer and thus, were diminished with reduction of the residue. In many cases, gentle pressure applied through tissue greatly reduced the appearance of other marks. Once clean and lanolin-free, the surface could be lightly brushed with a soft bristle brush to further blend fine scratches and superficial marks. It is worth noting that this should be carried out under magnification with minimal pressure. The few gouges and cracks that could not be reduced will be reworked by the artist at a later date. In the case of detached fragments of coating, the pieces were warmed with a hot-air tool and then reattached.

Fig. 11. Before treatment (Denver Art Museum, 1992.548D) (Photograph by Liz Homberger)

Fig. 12. After treatment (Denver Art Museum, 1992.548D) (Photograph by Liz Homberger)

8. INSTALLATION

The most immediately damaging elements to these works are dust and the visitor’s hands, so preventive measures were undertaken to protect the works while on view. After discussions with the artist and curator, it was decided to protect *Untitled (Lipstick Urinals)* with a Plexiglas bonnet. A physical barrier placed about 20 inches above the floor was used to prevent visitors from handling *One Month Late*. Additionally, low light levels of five footcandles were advised because of the uncertainty of the lightfastness of lipstick; these levels also provided better color saturation.

Fig. 13. One Month Late and Untitled (Lipstick Urinals) installed in 2008 (Photograph by Liz Homberger)

9. STORAGE

Proper storage is essential to the preservation of the works. Before they are returned to storage each work will be cleaned to remove dust that has accumulated during exhibition using the same technique described above. Although the exact designs for the storage of the works were not finalized at the time of this publication, basic recommendations include: minimal contact between the coating and housing materials; use of silicone-coated Mylar where there is contact; maintenance of a stable, cool environment below 65ºF; and air circulation to prevent the establishment of a microclimate. In short, the works must be protected from dust, but also require a cool, stable environment with air circulation.

In the case of *One Month Late*, the ties will be stored vertically in order to minimize stress at weak points, such as at the knot, and also to adequately support the weight of the object. Previously, the shoes had been wrapped in Mylar and the ties were stored horizontally, face down in custom-cut foam channels covered with Mylar sheeting; this position led to the formation of stress cracks around the knots of the ties and a burnished, glossy surface where the droplets had been. Vertical storage should prevent undue stress on the ties. The shoes should be stored in custom-shaped channels that minimize contact but provide adequate support.

The urinals do not pose as much of a challenging issue since they can be stored lying on their backs: they will be stored in the same position as before, with the back of the (hollow) urinal flat on silicone-coated Mylar sheets. The sheets will be secured to a slide-out tray within a box that allows for protection from dust but also adequate ventilation.

10. CONCLUSION

Studies on the ageing of lipstick have described the factors that influence its deterioration. Despite its short life in its intended use, lipstick is actually quite durable as an art material, but also extremely vulnerable to external agents of deterioration. While the described treatment improved the appearance of the works, preventive conservation is essential to prolonging the life of lipstick-based art. Recommendations for work composed of or incorporating lipstick include: maintenance of a stable, cool environment (temperature around 65˚F or lower and relative humidity below 50%); protective barriers or vitrines with small fans to circulate air during exhibition; and protective housing that allows for air circulation and also minimal contact with the lipstick in storage.

Parallel tracks of inquiry informed the conservation and installation of Rachel Lachowicz's lipstick-based works. Materials research and collaboration with the artist were essential to the design of a treatment plan as well as the installation of the works. Analysis indicated that the main component of the sweat droplets was likely lanolin or a similar material composed of long hydrocarbon chains and esters. The separation of lanolin from the wax and oil mixture prepared by Lachowicz is similar to the process observed in commercially prepared lipsticks. The process is likely the result of multiple factors including the incompatibility of components, reheating of the lipstick mixture, and elevated temperatures and relative humidity related to the previous housing design. Further research into the composition of the coating may yield important information about lipstick and also further our understanding of its expected lifetime as an art material. It is hoped that the treatment and preventive conservation plans for the lipstick-coated urinals and ties can be applied to works composed of similar materials and that the overall approach may also serve as a model for other projects involving non-traditional materials and living artists.

ACKNOWLEDGEMENTS

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SOURCES OF MATERIALS

Groomstick (a non-vulcanizied cis-isoprene rubber)
Talas
330 Morgan Avenue
Brooklyn, NY 11211
(212) 219-0770

Acid-Free Unbuffered Tissue
Talas
330 Morgan Avenue
Brooklyn, NY 11211
(212) 219-0770

Silicone-Coated Mylar
Talas
330 Morgan Avenue
Brooklyn, NY 11211
(212) 219-0770

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DISROBING: RESEARCH AND PREVENTIVE CONSERVATION OF PAINTED HIDE ROBES AT THE ETHNOLOGICAL MUSEUM, NATIONAL MUSEUMS BERLIN, GERMANY

ANNE TURNER GUNNISON, HELENE TELLO, PETER BOLZ, AND NANCY FONICELLO

ABSTRACT

The North American collections at the Ethnological Museum in Berlin, Germany include a selection of 18 painted bison and cattle hide robes. Within this collection are seven rare and early examples of bison robes, collected in the 1830s by Prince Maximilian zu Wied on his travels along the Upper Missouri River. Due to their size, the robes present a challenge for the museum to store, exhibit, document, examine, and conserve. For almost 20 years, 14 of the robes were inappropriately stored, hung from trouser hangers clamped along their edges, in a case with limited access. This method of storage made it difficult to examine the objects for ethnological and conservation research.

An extensive preventive conservation project was undertaken to re-house the robes horizontally on trays, in a purpose-built storage unit. The robes were documented and condition checked. The project also incorporated an in-depth study of a Piegan (Blackfoot) robe collected by Prince Maximilian. This study included identifying the dyes and pigments used in the quillwork and painted iconography, using high performance liquid chromatography and Fourier transform infrared spectroscopy. Experiments in dyeing quills with native dye material and using these dyes as paint on tanned bison hide were also undertaken.

As pesticide contamination is a prevalent problem in the Ethnological Museum collections, it was decided to identify and quantify the possible chemicals, including chlorine containing compounds like dichloro-diphenyl-trichloroethane, lindane or polychlorocamphene, and heavy metal compounds like mercury(II)-chloride or arsenic trioxide, used on this robe, as well as two others, using gas chromatography-mass spectrometry and inductively coupled plasma mass spectrometry. Mercury was found at extremely high levels; this will present enormous problems when these objects are handled and studied. Current and future work must be carried out under strict protocol, including the use of suitable personal protective clothing.

1. INTRODUCTION

The Ethnological Museum of the National Museums Berlin, Germany, which has its origins in collections from the 1500s, houses approximately 30,000 North American objects. Among these holdings is an 1844 acquisition of 47 objects, collected between 1832 and 1834 by the German explorer and naturalist, Prince Maximilian zu Wied during his expedition with Swiss artist Karl Bodmer up the upper Missouri River in the western United States. Included in this purchase were 11 painted child and adult-sized bison robes. Eight of the adult size robes remain. The museum has 10 other painted adult-sized robes from a variety of North American Indian tribes collected between the early 1800s and early 1900s. This paper will discuss the re-housing of 14 of these hide robes, and a more thorough investigation of one.

The initial objective of the project, which began in 2007, was preventive conservation: to assess the overall conditions of the robes and to implement a more sympathetic storage environment, enabling easier access. Fortunately, time allowed for an investigative project of one Blackfoot, or Piegan robe, catalogued as IV B 199, collected in 1833. While work is still ongoing, identification of the dyes and pigments used on the robe was attempted in order to understand the original cultural context of the Piegan tribe during early years of contact with fur traders and explorers. Secondly, as contamination of the robe with pesticides was likely, we identified the pesticides present, as to inform future handling and study.

2. THE RE-HOUSING PROJECT

Four of the bison robes are on permanent display. For the past 20 years or so, thirteen robes were kept in a glass-front, upright storage case in the permanent storage of the American Ethnology Department. The robes were hung with trouser press hangers clamped along the edges, and the hangers were hung on cords strung across the case. Because of inadequate space within the case, the robes were extremely difficult to access, preventing examination in any detail.

Helene Tello, objects conservator for North and South American collections, Peter Bolz, curator for North American collections, and Mario Graber, conservator for leather and related materials, decided that these robes should be removed from this case, and stored flat in a purpose-built storage unit within the collections area.

Fig. 1. The old storage case (Photograph by Helene Tello)

Ms. Tello and Mr. Graber removed the robes and temporarily stacked them on a table. Anne Gunnison, an intern from the MSc course for Conservation for Archaeology and Museums at the Institute of Archaeology, University College London, subsequently assisted with condition checking the robes and thoroughly documenting with photographs. All information and images were entered into the museum database.

Because pesticides containing organochlorines and heavy metal compounds were historically used on the collection, all work in close proximity to the robes was done wearing facemasks, zip-up Tyvek suits and nitrile gloves. Wearing this equipment can be tiring when lifting heavy robes, but was necessary.

The robes are in a variety of conditions; some have clearly suffered from pigment loss, moisture damage, staining, and inappropriate conservation treatment, including the application of large patches to repair losses. While a majority of the robes are made of bison hide, a few are likely cattle hide, indicating a later date of production and collection. Cattle hides were used during the reservation period after the bison population had been severely depleted, and most Native Americans had been removed to reservations by the late 1800s to early 1900s (Dempsey 2007, 58; Bolz 2008).

A new storage cabinet was constructed with MDF-board, wood crossbars, and gaskets by the in-house carpenters who work for the National Museums, Berlin. The trays are constructed wood frames, covered with Tyvek that is secured with stainless steel staples. Wood components were treated with neemspray, a liquid insecticide and fungicide.

Fig. 2. Helene Tello removes robes from the old storage case
(Photograph by Lars Malareck, Ethnological Museum, Berlin. Used with permission)

Fig. 3. The robes were examined and assessed while wearing personal protective equipment
(Photograph by Ines Seibt, Ethnological Museum, Berlin. Used with permission)

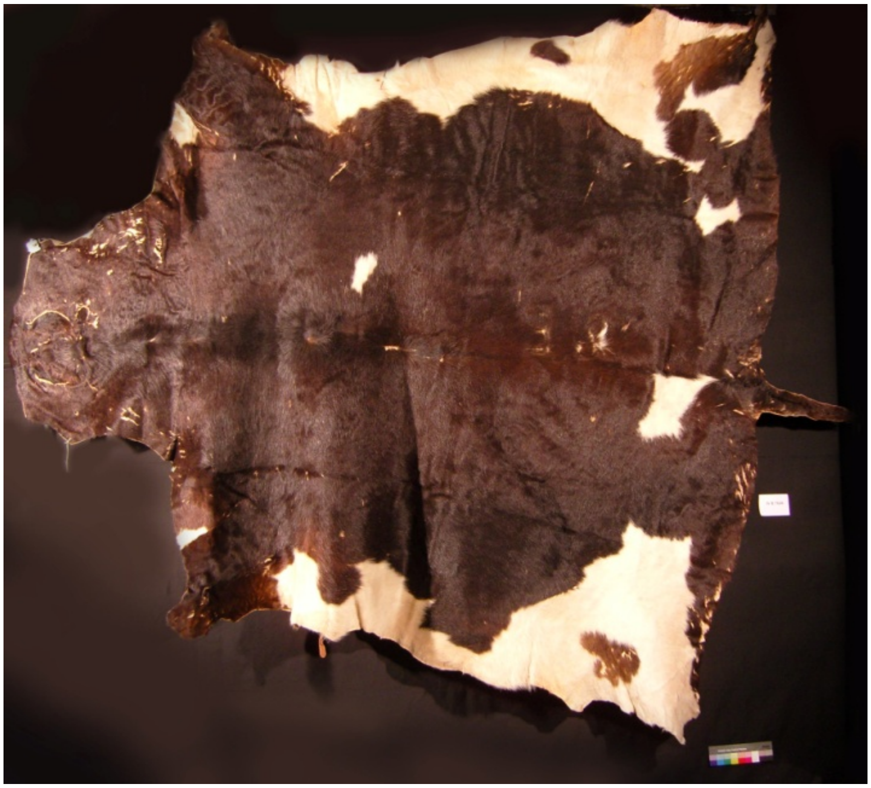

Fig. 4. A cattle hide robe, IV B 7626, Ethnological Museum, Berlin
(Photograph by Anne Gunnison and Helene Tello. Used with permission)

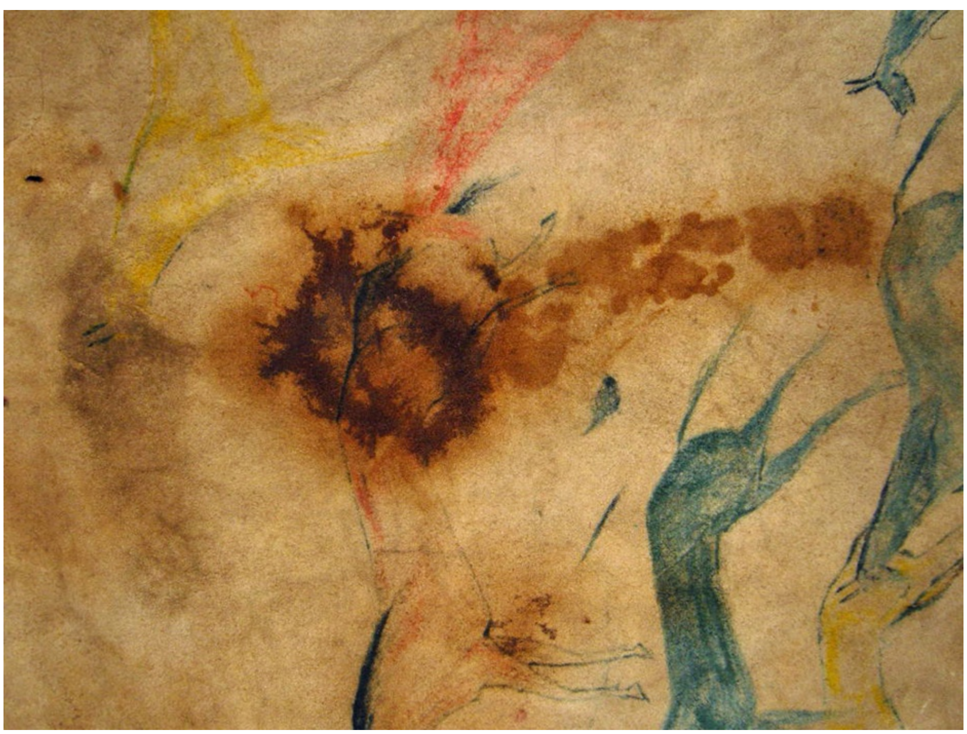

Fig. 5. Staining on a hide robe V B 7968, Ethnological Museum, Berlin
(Photograph by Anne Gunnison and Helene Tello. Used with permission)

Fig. 6. The new storage case (Photograph by Lars Malareck, Ethnological Museum, Berlin. Used with permission)

2.1 FURTHER STUDY

One robe, IV B 199, was chosen for further study because of its history within multiple contexts. It is a significant piece for its early collection date. There are few North American hide objects that date before 1800 within any museum collection; other robes described as "early" are dated from the 1840s to the 1860s (Dempsey 2007).

Prince Maximilian's journals from the expedition between 1832 and 1834, were published in English in 1843, with accompanying illustrations by Karl Bodmer. The most recent translation was published in 2008. Maximilian's first-hand accounts and Bodmer's illustrations give insight into many tribes including the Piegan tribe, from whom the robe originated, as well as materials and technologies utilized by the makers to create these robes (Maximilian 1843; Witte et al. 2008). Maximilian's detailed descriptions of painted buffalo robes were some of the earliest written (Dempsey 2007).

The robe's more recent history as war booty taken by the Red Army to the Soviet Union after World War II is also considered significant. An estimated 5,800 objects from the North American collections including six hide robes were unaccounted for after the war. The robe spent time in Leningrad, today called St. Petersburg, and later in Leipzig, in former East Germany. Little is known about its time in the USSR, but it was amongst the objects secretly transferred from St. Petersburg to the *Museum für Völkerkunde* in Leipzig in the 1970s (Bolz and Sanner 1999, Bolz 2008).

In 1990, after German reunification, 45,000 ethnographic objects in Leipzig, including the robe, were returned to the National Ethnological Museum collections in Berlin. Some objects that were thought lost, reappeared, although many in disrepair. Many objects are still unaccounted for (Bolz and Sanner 1999).

Fig. 7. Robe IV B 199, Ethnological Museum, Berlin
(Photograph by Anne Gunnison and Helene Tello. Used with permission)

Fig. 8. From the journal of Prince Maximilian zu Wied (From Witte et al. 2008)

3. THE ROBE—IV B 199

Examining the bison robe in more detail, the hide was semi-tanned, most likely using animal brains as the tanning agent, and the hair left intact. Holes cut around the edge to stretch the hide for the tanning process remain. The edges are fringed.

There is a sinew-sewn seam lengthwise down the centre, indicating the hide was tanned in two pieces and re-sewn. Most of this seam is covered on the flesh-side by a separate strip of hide decorated with yellow, orange, and white quillwork, with an additional brown plant fibre component. The orange and yellow quills are dyed, while the white is likely un-dyed. There is a small patch of vibrant red textile that has been sewn onto the flesh-side of the robe.

The flesh-side of the robe has been painted with human figures, guns, bows, quivers, and other items using three different colours: green, orange, and a dark brown. The ears of the bison that remain on the hair side are covered with quillwork and are decorated with hide fringe wrapped with quills.

3.1 COLLECTION HISTORY AND CULTURAL CONTEXT

The robe was likely collected at Fort McKenzie where Maximilian and Bodmer stayed from August to September 1833. Members of the Piegan tribe camped close to the fort, which was established in 1832. Before this time, there was little contact between the Blackfoot tribes and fur traders (Maximilian 1843).

The Blackfoot tribe is actually a blanket term for a nation of four tribes: the Blackfoot, now called Siksika First Nation; the Blood; the Kainia, now called the Kainaiwa First Nation; and the Piegans, or Pikuni, which are now divided into North Piegan, or Aputohsi-Pikuni, now called the Pikani First Nation, and the South Piegan, or Amiskapi-Pikuni, now called Blackfeet Indians of Montana. The tribe, which Maximilian calls Piekann, would be the Piegan or Pikuni. The Blackfoot territory extended from Battle River in Alberta, down to the Missouri River in what is now Montana (Dempsey 2007).

During the 1830s, bison were the most important commodity to Plains Indians tribes. The Blackfoot were no exception. The bison were used for food, shelter, medicine, tools, and of course, as a source of clothing. Maximilian wrote specifically about the use of robes as a garment:

> The chief article of their dress, the large buffalo robe, is, for the most part, painted on the tanned side... Others, again, are painted with representations of their warlike exploits, in black, red, green, and yellow. The figures represent the taking of prisoners, dead or wounded enemies, captured arms and horses, blood, balls flying about in the air, and such objects. Such robes are embroidered with transverse bands of porcupine quills of the most brilliant colours, divided in to two equal parts by a round rosette of the same. The ground of the skin is often reddish-brown, and the figures on it black. All the Missouri Indians wear these robes… During the summer, the fur is worn on the outside, and in winter inside. The right arm and shoulder are generally bare... (Maximilian 1843, 248-249)

Fig. 9. Detail of quillwork on seam, red textile patch, and painted images on IV B 199, Ethnological Museum, Berlin (Photograph by Anne Gunnison and Helene Tello. Used with permission)

Fig. 10. Detail of quillwork on ears on IV B 199, Ethnological Museum, Berlin (Photograph by Anne Gunnison and Helene Tello. Used with permission)

Fig. 12. *Piegan Blackfeet Man*, Karl Bodmer (From Moore 1997)

3.2 CONDITION

The robe is in stable condition. However, stiff creases in the hide have caused damage and loss of quill and plant material in the decorative elements on the central seam. There are areas of staining and discolouration, including rust, across the surface of the flesh side. The hide is not as malleable as descriptions of robes in use may suggest. It has apparently suffered from exposure to moisture, which could have occurred at several points in its history.

Maximilian wrote, "[A]s the boat had no deck, and we found to our great dismay, that this new vessel was very leaky so that the greater part of our luggage was wet through… When the sun had risen a little higher, we landed on the south bank, and made a large fire… Our drenched buffalo robes and blankets were brought on shore to dry" (Maximilian 1843, 287).

It has been said that many of the war spoils were transported to the Soviet Union in open boxcars during the winter, thus leaving them exposed to inclement weather. Exposure to excessive moisture was also possible in Leipzig, where there was a large flood in the collections of the museum in the 1980s. It is also possible an aqueous pesticide or insecticide was applied during this time (Bolz and Sanner 1999).

3.3 PREVIOUS TREATMENT

Heavy metal compounds, such as arsenic and mercuric salts, were in use by the 1830s by naturalists and explorers to preserve organic objects (Hawks 2001). These types of preservatives may well have been utilized by Maximilian, although he does not mention them in the 1843

English translation of his journal; he does mention the use of brandy alcohol to store animal specimens (Maximilian 1843).

Aware of the destruction wrought by pest infestation, Maximilian wrote of an American colleague's collection, "Mr. Say's entomological collection was continually damaged by the rapacious insects, which are much more dangerous and destructive here than in Europe" (Maximilian 1843, 87). But he also noted, "The furs in the interior of North America are free from a nuisance so common among us, I mean insects, especially moths, which are unknown on the Upper Missouri" (Maximilian 1843, 189).

Because of the robe's overall good state of preservation, it was assumed that it had been treated with a pesticide at some point in its history.There are no known written records of treatment performed on this object during its time in St. Petersburg or Leipzig. It is known that the insecticide dichloro-diphenyl-trichloroethane, or DDT, was used in great quantities (Tello 2008). It is also known that objects in the German Democratic Republic were treated with an insecticide Texyl-Spray, which was varying formulations of lindane and polychlorocamphene or lindane and permethrin (Graber 2008).

Six robes, including IV B 199, were returned from Leipzig folded in wooden cases. They were stiff, dry, brittle, and difficult to unfold and were treated by the leather conservator Mr. Graber in 1994 and 1995 (Graber 2008). Mr. Graber detailed his treatment of the returned robes. They were left in a fume hood for several weeks to ventilate. The hair and flesh sides of the robe were cleaned and a leather softener, Lederweicher, applied. The robes were unfolded and weighted heavily in an attempt to flatten them. A fungicide called Lysoform was also applied (Graber 2008). This application of the leather softener may have helped flatten the robe, but the moisture imparted may have, over time, resulted in the current stiffness of the hide.

4. SAMPLING AND ANALYSIS

As noted above, at the time of Maximilian's travels to Fort McKenzie, trade contacts with Blackfoot groups were still relatively new. It was of interest to this project to understand whether the Blackfoot tribes had begun to utilize new materials, still employed the old methods, or used a combination.

Whether the robe had been treated by pesticides was also of interest. This helps inform what to expect on other robes in the collection, especially those returned from Leipzig, and how to develop handling guidelines to mitigate any health risks.

Some pigment analysis has previously been completed. In one area, there is residue of a red pigment on the surface of the robe. In 1998, Ms. Tello had a small sample of the red analyzed by x-ray fluorescence, or XRF. The tests revealed a significant concentration of mercury, seemingly indicating the presence of vermillion pigment. However, as research results will indicate below, there may be another reason for the presence of mercury.

Using a scalpel and tweezers, samples of the yellow and orange quill, the brown fibre component of the quillwork, and the orange, green, and brown pigments or dyes were removed on the flesh side, and a white crystalline substance found on the flesh and hair sides of the robe was also removed. One gram of hair was pulled off from across the surface of the hair side of the robe.

Fig. 14. Sampling locations on the robe IV B 199, Ethnological Museum, Berlin
(Photograph by Anne Gunnison and Helene Tello. Used with permission)

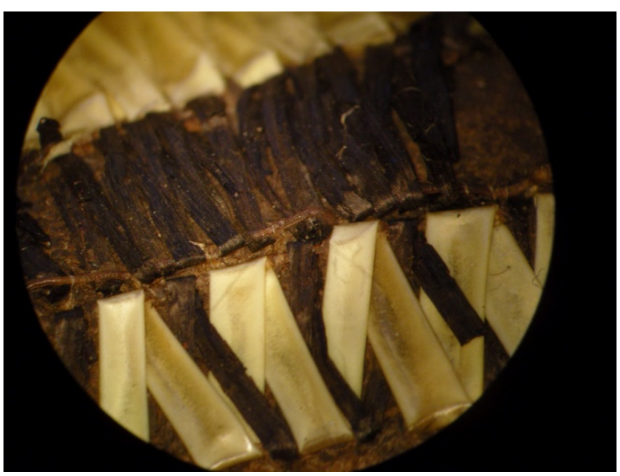

Fig. 15. Plant fibre component of quillwork on IV B 199, Ethnological Museum, Berlin (Photograph by Anne Gunnison. Used with permission)

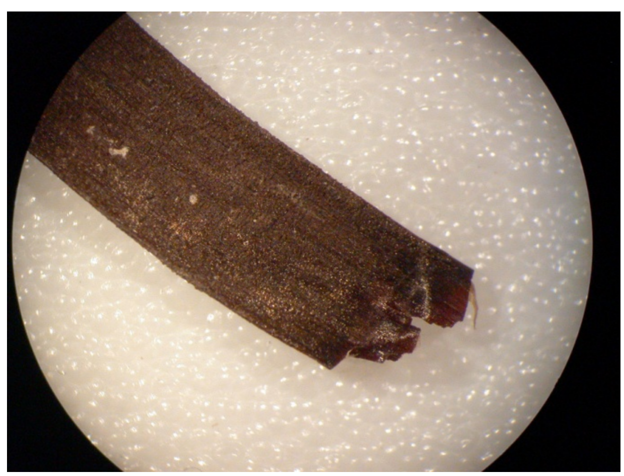

Fig. 16. Detail of known Horsetail (Equisetum spp.) root. (Photograph by Anne Gunnison)

The brown in the quillwork on the robe is likely from the root of the *Equisetum* plant, commonly called 'horsetail' as suggested by Nancy Fonicello, a specialist in quillwork (Fonicello 2008). Bill Holm noted in his monograph, "Quill-wrapped horsehair: two rare quilling techniques," "black was a difficult colour to achieve in dying quills in the early nineteenth century, and dark brown or black vegetal matter was often substituted, probably the rhizome of the horsetail" (Holm 2001, 59-60). George Bird Grinnell in his 1923 account "The Cheyenne Indians" also references the use of the *Equisetum* species by Cheyenne quill workers (Grinnell 1972, 167).

There is scant information about original quill dyeing recipes, and there has not been to date a considerable amount of analytical work done to identify quill dyes used by Native American tribes in different geographical regions. Maximilian did record in his journals of the Blackfoot that quill workers, "to produce the beautiful yellow colour, they employ a lemon-coloured moss from the Rocky Mountains, which grows in the fir trees… A certain root furnishes the beautiful red dye, and they extract many other bright colours from the goods procured from the Whites. With them they dye the porcupine quills and the quills of the feathers…" (Maximilian 1843, 249-250).

Two colours of dyed quill are represented on the robe: a yellow and an orange/orange-red. Ms. Fonicello believed that these colours could have been produced by native, natural dyes, including dock root or wolf moss for the yellow, and bloodroot for the orange-red.

Maximilian noted in his journals that the samples of the vegetal dyes described were among the part of collections that were lost when they were shipped, but his descriptions correspond to wolf moss, and bloodroot.

Using raw materials from the root of dock plants (*Rumex crispus*), wolf moss (*Letharia vulpine*), and bloodroot (*Sanguinaria canadensis*) gathered in Montana by Ms. Fonicello, and following her dyeing instructions, new porcupine quills were dyed to create a visual comparison with the quills on the robe. The colours obtained, most particularly, from the bloodroot and the wolf moss, were similar to those found on the robe, thus making it plausible that these were the dyes used.

Fig. 17. New quills dyed with bloodroot (Photograph by Anne Gunnison)

Fig 18. New quills dyed with wolf moss (Photograph by Anne Gunnison)

Professor Dr. Unger from the University of Applied Sciences in Potsdam completed preliminary high performance liquid chromatography (HPLC) analysis of the dyed quills and green painted hide. The samples from the robe as well as the reference materials, dye samples of wolf moss, bloodroot, and yellow dock, and quills dyed with these known materials, both prepared by Ms. Tello, were prepared for HPLC.

While this work is still ongoing, there are some preliminary findings. HPLC results show that the yellow quill from the robes was dyed with an unknown natural organic material. Yellow dock and wolf moss, however, were likely not used.

In the case of the orange quill, a colorant could be detected, but there were no indications for the application of an orange dye, indicating that bloodroot was not used. Ms. Fonicello has suggested another possibility for the orange-red quill dye: the root of the *Gallium* species, commonly known as bedstraw, which produces a madder-based dye. This has yet to be tested.

More testing for identification of pigments and dyes is planned for the future. Using previously published databases, such as that published in "Analysis of the paints used to decorate Northern Plains hide artifacts during the nineteenth and early twentieth Centuries," by Moffat, Sirois, and Miller, as well as historic accounts listing materials that may have been used by the Blackfoot tribes to guide our analysis, it is hoped that the dyes and pigments on the robe can be more specifically identified.

4.1 PESTICIDE ANALYSIS

When removing the hair sample from the robe with nitrile-gloved hands, we noticed that a shiny residue formed on the surface of the glove, indicating the object had been treated with a chemical. It was theorized that the crystalline substance, which can be seen on the robe, was DDT crystals, which occur when an object has been saturated with the chemical.

The hair was sent to the Analyse Labor Berlin (ALAB), where gas chromatography mass spectroscopy (GCMS) was used to identify organic compounds, and inductively coupled mass spectroscopy (ICPMS) to identify heavy metals. The preliminary results of this analysis were rather startling. While it confirmed the presence of DDT, it also confirmed the presence of mercury, likely a mercury(II)-chloride in surprisingly high and dangerous levels, with the initial results finding 10,000 mg/kg of sample (ALAB 2008; Tello 2008).

Values for the acceptable daily intake for humans are currently not available. But while an appropriate toxicology expert would be needed to analyze the exact risks, the material safety data sheet, or MSDS, for mercury(II)-chloride indicates that the lethal dose taken orally by a rat is 1mg/kg of body weight, while severe skin irritation, during an acute toxicity test, occurs on a rabbit with 500 mg over a 24-hour period (Environmental Health and Safety 2008).

This is sobering news for access and study of the collection. While precautions were taken, this information indicates that this robe could truly be highly toxic.

Fig. 19. A shiny residue on the surface of the glove (Photograph by Anne Gunnison and Helene Tello)

Fig. 20. Crystalline substance found on areas of robe IV B 199, Ethnological Museum, Berlin (Photograph by Anne Gunnison)

5. CONCLUSION

The re-housing and preventive conservation of the robes is an important step for the improvement of conditions for the historically significant collection. It has enabled greater access to the robes, some of which had never been seen or examined by the curator. It is now known, however, that greater access may also mean greater personal risk, as we have established the presence of hazardous chemicals on at least one robe. While the mercury-based pesticide may be the reason the robe is still in good condition, the consequence will be that extreme care must be taken when handling or studying the collection.

While work on the investigative conservation project is ongoing, the current research fits into a broader context of cultural knowledge, by elucidating a better understanding of the material culture and practices of Piegan tribe at the early stages of interaction with American fur traders. This data can be used in order to define the types of dyes and pigments one could expect to find on objects from a similar time period and region. It can also be used to identify dying recipes, which have been lost over time.

This research has the potential to expand. It would be an incredible opportunity to examine the entirety of the Maximilian collection and make the research more inclusive by collaborating with not only with conservation professionals, but also with the source communities. Descendents of many of the tribes Maximilian met still live in the United States and Canada. These source community members should be contacted and a more open discourse about these objects could be established, with a reciprocal exchange of knowledge.

Researching cultural, technological, and conservation histories and providing better access and storage conditions furthered the appreciation of this important collection of robes in the Ethnological Museum. It is hoped that data collected will also inform a greater knowledge and understanding of painted and quilled objects in other collections in Europe and the Americas.

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THE ANCHORAGE PROJECT: GUT DECISIONS IN CULTURAL AND MUSEUM CONTEXTS

LANDIS SMITH, KELLY MCHUGH,
MICHELE AUSTIN DENNEHY, AND KIM CULLEN-COBB

ABSTRACT

The Smithsonian Institution's National Museum of Natural History and the National Museum of the American Indian are presently involved in a joint loan of approximately 600 objects to the Anchorage Museum of History and Culture. These objects are part of a project entitled, "Living Our Cultures," created by the Smithsonian Institution's Arctic Studies Center, which will be housed in the new wing of the Anchorage Museum. The premise behind this loan is to increase Alaskan access, knowledge, and use of the Smithsonian Institution collection, primarily by Native Alaskans. The loan for these objects is slated for a 12-year duration; however, there will be continual Smithsonian Institution object rotation well into the future.

The regional focus of this project provides a distinct opportunity for Smithsonian Institution conservators to concentrate, for an extended period of time, on the diverse materials, technologies and histories offered by these artifacts. Eleven cultural groups located throughout Alaska are represented in the exhibit. Currently, we are working on the treatment and preparation of selected objects from the Bering Sea cultures. The dependency on marine mammals for survival is illustrated in the number of artifacts made from the inner and outer skins of whales, seals, walruses, and sea lions. While there is a significant amount of information regarding outer skins, the conservation literature on inner skins is limited.

The unusual properties of gutskin can be somewhat intimidating to conservators working outside the Arctic region, who do not treat it on a regular basis. The opportunity to utilize two large comparative institutional collections, while having access to curators working with Arctic collections, marine mammal biologists, Native Alaskan consultants, contemporary gutskin artists, and conservation scientists prompted us to undertake a comprehensive study of this material in order to increase our understanding and inform our treatment decisions. This paper will report on results of our investigation and will hopefully stimulate a cooperative and expanded study with other conservators and artists working with this amazing material.

1. AN OVERVIEW: THE ANCHORAGE PROJECT AND CONSERVATION APPROACH

In the spring of 2010, the National Museum of Natural History's (NMNH) Arctic Studies Center (ASC) will open a permanent home in the new wing of the Anchorage Museum. Representing eleven major Alaska Native culture groups, approximately 600 Smithsonian (SI) objects - 400 from NMNH and 200 from the National Museum of the American Indian (NMAI) - will be included in the inaugural exhibit, *Sharing Our Cultures, Sharing Our Heritage: The First Peoples of Alaska.* From its inception, increased access to collections for Native people and the inclusion of Native voice have been organizing principles of the entire project. Further, an unprecedented level of access will be implemented in the ASC where requested objects may be removed from exhibit and brought to a specially designated study room for close study, consultation or other purposes. For conservators working on this project, the value of access is constantly weighed against the physical risk to the objects, acknowledging that it is only through access to the conservation and curation process that a fuller understanding of the objects is possible. Through collaborative and comprehensive work with collections, both the tangible and intangible aspects of objects are identified and preserved. Our work in Washington DC is seen as a foundation for the real work that will occur once the objects are in Alaska, in proximity to Alaska Native communities.

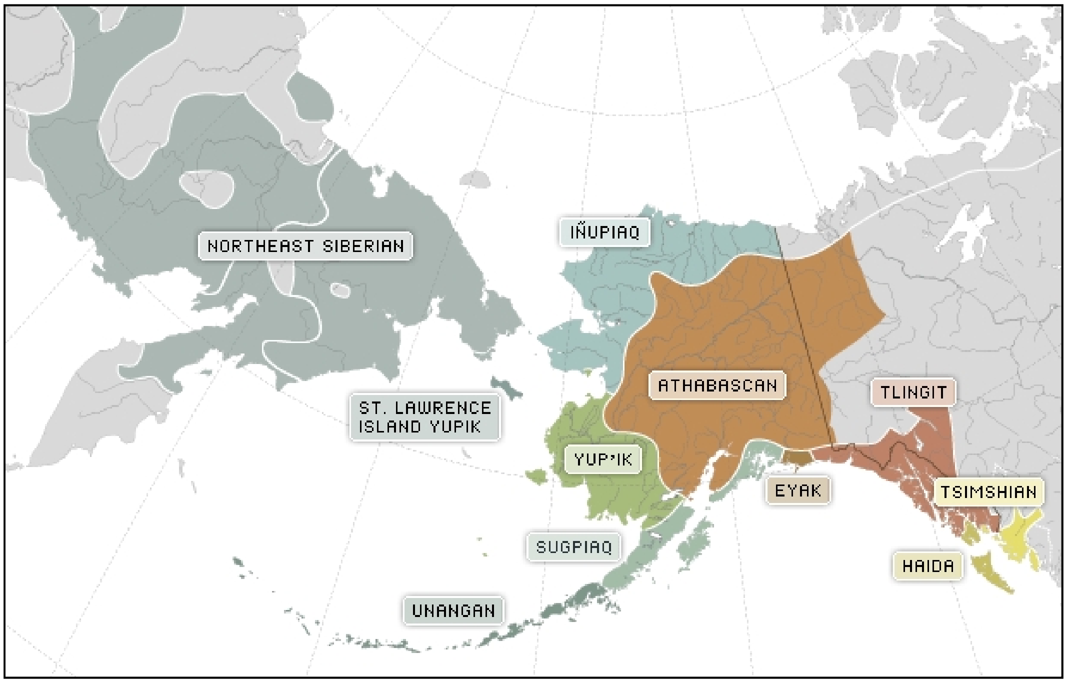

Fig. 1. Map of Alaska with the Alaska Native cultures included in the exhibit (Image courtesy of www.alaska.si.edu)

The conservation phase of the Anchorage Project has been a three-year period of intensive work with a wide range of Alaska Native objects. From Sugpiaq walrus ivory game pieces to Yup'ik painted driftwood boxes and Inupiaq skin garments, the objects present a great diversity of materials, technologies, histories, aesthetics, and conditions. The challenge has been to contextualize the objects as much as possible in terms of their cultural and museum histories, and to ground conservation decisions and documentation in a holistic understanding of the objects. Developed primarily for documented anthropology collections, the conservation process was designed by Landis Smith to methodically incorporate and synthesize information from multiple sources, the objects considered from several different perspectives at once.

Along with a basic familiarity with culture and landscape, the conservation process begins with curatorial consultations and museum records such as catalogue and accession notes, 19th century ledger book entries and drawings, conservation records, early images, and background information on the collecting practices of the early NMNH ethnographers in Alaska. Investigations regarding the cultural use of objects, whether an object was made for trade or sale, the exhibit history of the objects, materials and technologies and the cultural meanings of objects all inform the conservator's examination and assessment of the condition of the object. Further, the deep collections of the NMNH Anthropology Department offer a reference for object types and conditions.

The resources of other NMNH science departments have been brought to bear in the conservation process as well; in particular, the Ornithology Department and Division of Mammals offer conservators the opportunity to view whole animals to identify and understand their parts, and why and how those parts were used. In addition, conservation scientists at the Museum Conservation Institute (MCI) have helped answer questions with, for example, x-radiography to reveal construction techniques, x-ray fluorescence to distinguish between Native and museum–applied coatings, and the rate of light fading on organic objects using the microfadeometer.

This background work, examination and analysis are critical to understand the objects with which we are working; however, consultations with Native advisors offer perspectives and knowledge otherwise unavailable. In keeping with the curatorial work for this project, Alaska Native consultants have been central to the conservation treatment decision-making and documentation process. Consultations are carefully planned and designed to allow for Native consultant-led discussion and focus. Consultations can offer invaluable insights into aesthetic and cultural preferences for the presentation of objects, as well as information about materials, technology and use. Native consultants help ensure the preservation of cultural meanings of these objects.

At the same time, consultations are ideally exchanges that flow both ways. In particular, old objects inspire the work of visiting artists, the telling of stories and recounting of memories. Objects and the materials from which they were made are discussed and named in Native languages, the collections' preservation inextricably tied to the preservation of language and the traditions the objects embody.

Over the three years of the Anchorage Project, conservators have been engaged in a dynamic process of examination and analysis, study of the museum record, early ethnographic accounts and field notes, Native consultations, and curatorial and other expert consultations. Yet, this work is only a beginning; a solid foundation of information and documentation on which to base continued work once the objects are in Alaska. There, the relative proximity of Alaska Native communities will allow for more conversation and consultations with more people, increasing our understanding of these objects, their preservation and conservation.

Fig. 2a. Sources of background information: Edward W. Nelson's book (Photo by Edward W. Nelson; courtesy of the National Anthropological Archives, Smithsonian Institution) 01425800

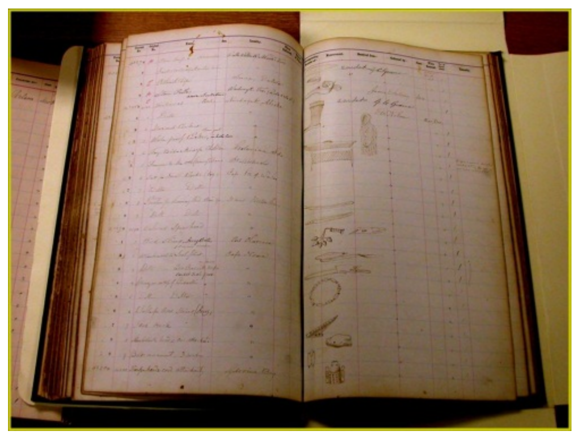

Fig. 2b. NMNH ledger book of accessions

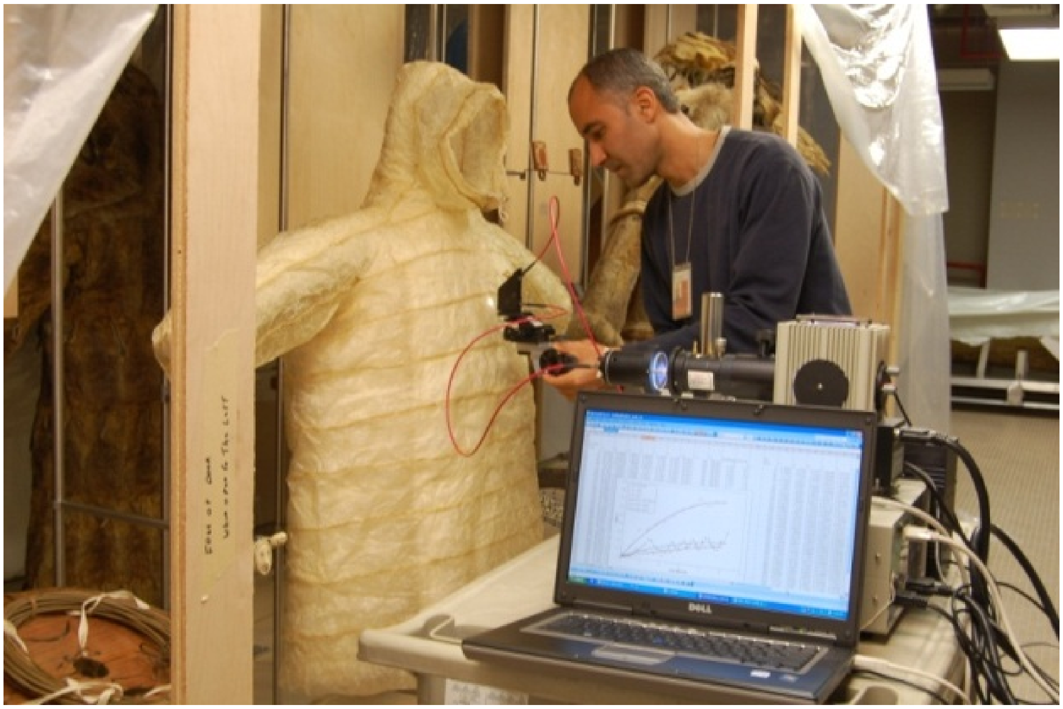

Fig. 3. Julio del'Hoyo, Fellow at the Museum Conservation Institute using the microfadeometer. (Photographs by Kim Cullen Cobb)

Fig. 4. Project conservators working with the National Museum of Natural History's Vertebrate Zoology Department (Photograph by Kim Cullen Cobb)

Fig. 5. Chuna McIntyre (Yup'ik) and Vernon Chemegalria (Yup'ik) consult object history, provenance and background records (Photograph by Molly Gleeson)

Fig. 6. Carver, George Bennett (Tlingit), examines surface of bentwood box (Photograph by Kim Cullen Cobb)

Fig. 7. Discussion with carver David Boxley (Tsimshian) (Photograph by Kim Cullen Cobb)

2. A FOCUS ON GUTSKIN

The interdisciplinary approach adopted for this project inspired a broad inquiry into how to best conserve objects constructed from the inner organs of Arctic sea mammals. These mammals, the whale, walrus, and seal, have provided the raw material for the manufacture of finely made utilitarian objects now in SI collections. The renewed focus on and interest in this material is based on the significant and recurring problems found with gutskin materials from both the NMAI and NMNH collections. Common problems include weak, embrittled skins, many with tears and distortions. Old museum treatments using various adhesives have stiffened the skin and failed attempts to lubricate the dry gutskin with humectants have left the skins discolored and oily. The goal of this project is to integrate the information from many sources to gain a more complete understanding of this complex material and develop an informed conservation approach.

This inquiry, still in the early stages, involves multiple avenues including a rich historical record, the wealth of knowledge held in source communities where gutskin objects are still made, techniques of contemporary artists creating with this material, and the work of research scientists, anthropologists, and conservators. During this investigation, NMAI was able to invite an expert Native Alaskan gutskin sewer to SI to work on a Saint Lawrence Island ceremonial parka that would be returning to Alaska with this loan. A summary of her treatment approach and philosophy, which prompted many lively discussions, is included.

2.1 MATERIALS AND THE LANDSCAPE

The circumpolar world has one of the more formidable climates on earth, and encompasses regions that are both remote and climatically harsh. It is home to indigenous peoples who have relied on hunting as the chief mode of survival. In the coastal regions of the arctic, much of the food supply has historically come from hunting aquatic mammals. Hunting takes place on open water during summer, and on or through the ice during winter. Inhabitants of the northern Bering Sea and Bering Strait, particularly of the islands, have lived and hunted astride one of the richest and most concentrated marine mammal migration routes in the world, with animals passing through this funnel twice annually. Communities base their hunting on these brief but predictable migrations. The seasonal movement of ice largely determines these migration routes (Stoker 1993).

This reliance on sea mammals produced a very distinctive material culture that can be seen repeated through many areas of the arctic; a material culture characterized by resourcefulness, adaptability, technological creativity, innovation, and ingenuity. Ceremonies and rituals imbued with this close relationship with aquatic animals reflect the importance of these animals as a major source of raw materials, used for clothing, footwear, containers, and many other objects.

The specific marine mammal resources available to Native Alaskan communities through hunting or trade differed along the long Alaskan coast. This in turn influenced how materials would be used culturally. Some understanding of this landscape and what was likely to be used and why informs the conservation approach.

Fig. 8. Walrus (left) and bearded seal (right) (Images from internet sources)

2.2 HISTORICAL RESEARCH

Similarly, the historic record offers information, largely through the prism of naturalists, anthropologists, and collectors writing about Alaskan communities and their material culture. Some of the most comprehensive records come from nineteenth century Smithsonian field naturalists working in Alaska. For example, when stationed at Point Barrow in northern Alaska in the late nineteenth century, Smithsonian collector and naturalist, John Murdoch, noted that the local communities made gutskin garments from seal and walrus, relying predominately on the abundant ringed seal population (Murdoch 1899). In addition, late nineteenth century naturalist and collector, Edward Nelson, who traveled extensively in Alaska, wrote of the qualities of his gutskin parka commenting that it was strong and could usually withstand the pressure of the water even when one was submerged beneath the combing sea, but failed in the surf where the weight of the water striking heavily from above would tear them and permit water to enter the boat (Nelson 1892).

There is limited conservation literature that explores the treatment of gutskin. One important 1987 publication brings the writings of contemporary Native skin sewers, biologists, and conservator together. This is fiber artist Pat Hickman's book, *Innerskin Outerskin: Gut and Fishskin.* This small volume has served as an important guide for our work.

Fig. 9. Smithsonian scientist, Edward Nelson (From Nelson 1899)

2.3 CONSULTATIONS

There are many contemporary artists who use gutskin as their medium. Fran Reed, well-respected fiber artist and scholar, became a friend and mentor during her visit to the Smithsonian. She worked with us on developing methods for visual species identification, and provided the opportunity to gain a greater understanding of the working properties of gut by offering a place in the workshop she taught in June of 2007. This collaboration led to ideas for skin repairs that utilized the properties of the membrane. For example, using a technique of wet, raw gutskin layered together with pressure but without adhesive as a binding.

Specialists in the field of marine mammal biology and anthropology acknowledge that the greatest repository of information on gutskin resides in the Native communities. The consultations for this project have enriched our understanding of the working properties of gutskin (the material), the various uses and differences of available animals, and how the material was traditionally cared for and repaired.

Curatorial consultations with various communities beginning in 2003 resulted in content direction for the exhibit, as well as a reference website titled *Sharing Knowledge* (www.alaska.si.edu). An interview with Saint Lawrence Island elder and skin sewer Estelle Oozevaseuk regarding a ceremonial gutskin parka (NMAI 123404.000) is available on this site. As with most consultations, Estelle Oozevaseuk begins by first identifying the source of the materials. She identifies the gut as *maklak* (bearded seal) intestine, then discusses the time-consuming process of preparing the intestine for use:

> It took a lot of work to do that. We just cleaned the inside out - pour some water in and take it out so many times. And we use our thumb fingernail to take the outer part off. Then, when it is done, we turn it inside out. It took a lot of work. And then we scraped the inside very gently. When done, we put them in water to try and swell them up - my grandma taught me to fill them up with water and go like this [lightly tip bowl back and forth]. And they get water logged. Then we would wring them, and the water turned red. And we changed it [water] so many times, so many times, until the water turns clear.

Further she notes, "Ones that had not been cleaned in the water [enough] turn out to be a kind of yellow or reddish color. Walrus is not good for this kind [ceremonial parka]; only the bearded seal intestine is good for dress-up because they're thinner. Walrus intestine is tougher and thicker than these and wider. Female walrus intestine is thinner, better. Bull walrus is hard."

Fig. 10. Gutskin workshop with fiber artist Fran Reed, June 2007 (Photographs by Lucie Charbeneau)

Fig. 11. Estelle Oozevaseuk (Courtesy of www.alaska.si.edu)

These consultations help us understand not only what materials are preferred because of their physical characteristics but also how the materials are traditionally prepared. Discussions of problems in preparation such as insufficient rinsing may account for some of the discolored objects we see in our collections. Additionally, we have observed at least two types of processed gutskin, the whiter "winter gut" and the more transparent "summer gut." Estelle Oozevaseuk describes the processing of winter gut stating, "She took them out in wintertime and blew it up. And when they freeze she held them like that [wrapped around outstretched arms], tied them up and tied them up on the meat rack. And they stayed there for a long time. The coldness turned them white." We would like to understand more about what happens to the physical properties of gut during this process.

A well-sewn and waterproof parka was a life or death matter in an environment as brutal as the Arctic. These women, the skin sewers, were vital to survival. Thomas Tungwenuk, an Inupiaq advisor, notes that the skin sewers are traditionally treated with great reverence. In the past, when conflict arose from outside invaders, these women were hidden in secret caves so they would not be harmed. It is critical that the parka not only be sewn with extraordinary skill, but if it requires repair, it has to be done with the same effectiveness. Patches must prevent water from chilling the wearer and have usually been stitched using the same materials and techniques used to fabricate the garment. There are countless examples of native patch repairs on gutskin garments in the Smithsonian collections.

Fig. 12. Frances Usugan, Yup'ik woman holding inflated, dry guts (From Riordan 2007, 151)

Fig. 13a. “Summer” gutskin parka (NMNH E424209) (Photograph by authors)

Fig. 13b. “Winter” gutskin parka (NMAI 123404.000) (Photograph by authors)

2.4 REPAIR OF A SAINT LAWRENCE ISLAND CEREMONIAL GUTSKIN PARKA

The ceremonial parka discussed by Ms. Ooszevaseuk and selected for inclusion in this loan will be displayed along with other ceremonial objects from Saint Lawrence Island. The parka, torn in two locations, on the back of the hood and on the back, was also missing numerous auklet curls from its decorated front. The tears required stabilization prior to its return to Alaska. NMAI conservator Kelly McHugh, responsible for treating the parka, thought that a consultation with an expert skin sewer could help her work through proposed treatment choices. Elaine Kingeekuk, a skin sewer and doll maker from Saint Lawrence Island was willing to work with NMAI. Ms. Kingeekuk talked with staff by phone about the parka and discussed the traditional repairs of sewing a gutskin patch with sinew and why she felt it was the appropriate approach for this parka. Like the conservators on this project, she has seen failed adhesive repairs on museum objects and believes the adhesive will only stiffen the gut, making it more brittle and prone to further tearing in the future.

NMAI, with support of the Mellon Foundation, invited Ms. Kingeekuk to Washington DC to repair the damaged parka using traditional methods. She repaired the tears on the parka using winterized walrus gut patches sewn with sinew she prepared in the lab. Patches were applied to both sides of the tear and carefully sewn in place. She believes the old gut requires this amount of support. The opportunity to ask her questions about the properties of the material, to see how wet she made the gut to manipulate it and execute the repairs was invaluable. The entire process was documented both with digital photography and digital video.

Elaine's visit has generated excitement, dialogue, connection and greater understanding. Her experience and ease of handling the gutskin has contributed to our understanding of the flexibility and limits of the material, which informed other treatments for the project. Our working relationship with her and her welcoming teaching method gave us the confidence to proceed with reshaping a Yup'ik gutskin/esophagus bag and an Aleutiiq gutskin parka in the traditional manner, through the direct application of water rather than our usual course of slow humidification. Ms. Kingeekuk commented that slow reshaping (as through humidification) could apply variable stress to the gutskin and could potentially cause damage. She has repeatedly reminded us that as a membrane, it wants to be wet, as it is in its natural state.

Fig. 14. Elaine Kingeekuk, Saint Lawrence Island Yup'ik, repairs NMAI parka (123404.000)
(Photographs by Anchorage Project conservators)

2.5 DISCUSSION

During the course of this process, the benefits and ramifications of a conservation approach that utilizes traditional repair or reshaping methods were discussed at length, in the context of our overall, integrated approach to the objects. These discussions included comparisons regarding the efficacy of puncturing the gut fabric to sew a patch versus the application of an adhesive that might stiffen the gutskin. Both treatments can be seen as invasive. Should we be putting an adhesive repair on a garment made to withstand the elements? Are we compromising what it was meant to do by applying a repair that would fail in use? Or do we turn a corner once an object is in a museum and no longer "in use"? The answer likely stems from where you sit. Elaine believes this parka still requires the same level of treatment it would receive at home; it is still an "active" garment and a part of the Saint Lawrence Island community. A traditional museum perspective might be that the garment's role is primarily one of education and scholarship. Each museum's perspective is directly related to its mission.

The decision to have Ms. Kingeekuk repair the parka using traditional methods is in line with NMAI's belief that the garment is part of a living culture and should be treated as such. The decision to repair it as if it was an active part of the community is in keeping with the Museum's goals to recognize Native authority. Ms. Kingeekuk's repair will last as long as the garment lasts. Can we say the same about adhesive repairs – should we?

Each treatment decision is made on a case-by-case basis, taking into consideration the museum's mission, the requirements of the project, and most importantly, the requirement of the objects. In this case we looked at our treatment history, considered different treatment approaches, and arrived at a solution that was more compatible with the gut fabric.

3. CURRENT RESEARCH

Our current research efforts are focused on integrating Alaskan Native knowledge with analytical tools such as SEM and mechanical testing, i.e. stress/strain. This will include identifying the possible visual distinction between various aquatic mammal intestines, differences and similarities between winter and summer gut, looking carefully at the effects of the repeated wetting and drying on gut, and the effects of adhesives on the membrane. Former NMAI Mellon fellow Lauren Horelick, together with Kelly McHugh and Odile Madden, carried out a research project on the effectiveness and effects of adhesives commonly applied on gut skin for tear repair (Horelick et al. 2011). It is our intention to collaborate in these efforts, particularly with conservators working on material from the circumpolar region, like Amy Tjiong, Linda Liu, and Ellen Carrlee. Research will continue at the Smithsonian in the fall of 2012 with a group of visiting Yup'ik traditional garment and gutskin sewers. The women are part of a project organized by anthropologist, Ann Fienup-Riordan, with a conservation component organized by Landis Smith.

ACKNOWLEDGEMENTS

Our dear colleague, gutskin artist Fran Reed died recently. We remember her for her open and generous spirit and for her driving curiosity and extensive knowledge of this material.

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CONSERVATION AT KAMAN-KALEHÖYÜK, TURKEY, 2008

ALICE BOCCIA PATERAKIS

ABSTRACT

The activities of the Conservation Department of the Kaman-Kalehöyük excavation in Turkey are reported as of 2008. The annual conservation student internship program has been reinstated and emphasis is placed on the conservation student research projects. An iron and a bronze stabilization project dating from 1999 to 2001 have been assessed and the results presented in abbreviated fashion. Plans for the expansion of the Japanese Institute of Anatolian Archaeology and the new museum at Kaman are outlined.

1. THE EXCAVATION

The excavation of Kaman-Kalehöyük commenced in 1986 by the Japanese Institute of Anatolian Archaeology under the auspices of the Middle Eastern Cultural Center in Japan (fig. 1). Located approximately 104 km southeast of Ankara, the site is a city mound or 'tel' of approximately 280 meters in diameter and 16 meters in height. The site lies along the ancient Silk Road trade route and represents three main cultural levels: Islamic, Iron Age (Phrygian), and Bronze Age (Hittite Empire, Old Hittite and Assyrian Colony period). The excavation provides a rare glimpse into the life of a rural settlement in Anatolia between the early Bronze Age (2300 BC) and the end of the Ottoman period (17^{th} c).

Fig. 1. Kaman-Kalehöyük excavation (Photograph by the Middle Eastern Cultural Center in Japan)

2. CONSERVATION

Conservation has been an active element of the excavation since 1986 contributing to the successful collaboration today between conservators, archaeologists, and related specialists at Kaman-Kalehöyük. The site has produced thousands of artifacts. Most of the objects are in storage at the campsite, though a small part of the collection is housed in the Kirşehir Museum, located 30 miles from the excavation. Conservation assists the archaeologists and the other specialists including archaeometallurgists, zooarchaeologists, osteoarchaeologists, archaeobotanists, and geoarchaeologists in the retrieval of maximum information from the objects by carrying out material characterization examinations, technical studies, sampling procedures for analysis, non-invasive and reversible conservation treatments, and preventive conservation measures for long-term preservation.

The activities of the Conservation Department fall into four broad categories: (1) active field conservation, (2) treatment of artifacts in the conservation laboratory, (3) research and education, (4) condition surveys and storage. Conservators participate frequently in the field, aiding the archaeologists in the consolidation and lifting of fragile artifacts. Conservators oversee packing required for the successful transport of artifacts to the conservation laboratory, located 2 km from the site, and between the storage areas and the museum. Condition surveys of the collection are carried out both in-house (2 km from the site) and off-site in the Kirşehir Museum (40 km from the excavation).

3. CONSERVATION RESEARCH AND EDUCATION

Glenn Wharton initiated the conservation student internship program in the early 1990s. The students are trained in the field and in the conservation laboratory. Each student selects a research project that focuses on conservation materials and methods for a particular material group or aspect of the Kaman collection. The conservation students and staff publish their reports at the end of the season in the journal *Anatolian Archaeological Studies (AAS)*, published in English by the Japanese Institute of Anatolian Archaeology. The Table of Contents for every issue of the *AAS* is available on the website of the Japanese Institute of Anatolian Archaeology, www.jiaa-kaman.org/en/aas/index16.html. Some of the student projects from past seasons are awaiting a final assessment and write-up. Two student projects, one dealing with the stabilization of iron and the other with the stabilization of copper alloys, were assessed and finalized in 2008.

3.1 IRON STABILIZATION PROJECT

In 1999 and 2000 Laramie Hickey-Friedman carried out two separate tests for the stabilization of iron artifacts: alkaline sulfite desalination and anoxic/desiccated storage. Hickey-Friedman treated iron from Kaman-Kalehöyük with alkaline sulfite: one group of iron artifacts was treated at Kaman and another group was treated at the University of Delaware, Winterthur (Hickey-Friedman 2000). They have been stored in polyethylene Ziploc bags with silica gel inside closed Tupperware-like containers in the Conservation Laboratory since the completion of treatment. The silica gel was regenerated annually. Laramie Hickey-Friedman also tested the Revolutionary Preservation System (RP System) for storage of a different group of iron objects (Hickey-Friedman 2001). In 2008, both projects were assessed by examining the condition of the objects in order to compare treatment methods and storage materials.

3.1.1 Alkaline Sulfite Method

The results showed very clearly that the alkaline sulfite treatment method must be followed exactly as described in the literature (North and Pearson 1978; Kaman-Kalehöyük 2002). In 2008 it was determined that the iron treated at Kaman was unstable whereas those iron objects treated in Winterthur were stable. The reason for this was determined to be inconsistency in treatment method: the objects were not sealed during treatment of the objects by immersion in alkaline sulfite in Kaman, thereby allowing exposure to oxygen and causing the sulfite scavenger to convert to sulfate and reduce the efficiency of the treatment. This may be attributed to inadequate laboratory equipment.

3.1.2 RP System

Laramie Hickey-Friedman also tested the efficiency of the RP System for storage of a different group of iron objects (fig. 2) (Hickey-Friedman 2001). In the RP System, the object is enclosed in an Escal bag with an oxygen absorber and an oxygen indicator. Due to limited supply, RH strips could not be placed in all the bags. The bag is either heat sealed or clipped shut with specially designed clips by Mitsubishi.

During the 2008 season the iron objects and storage bags from Hickey-Friedman's RP System tests were assessed (fig. 2). Oxygen had infiltrated to varying degrees, as indicated by the color of the oxygen indicator (pink indicates an anoxic environment). In 2008 the RH in those bags with RH strips was found to be very low: less than 10% RH. Therefore the oxygen absorber proves to be an extremely efficient desiccant over the long term.

Fig. 2. Kaman iron object 01000513, CO1-644 in Escal bag with oxygen scavenger. Blue color of oxygen eye indicates the infiltration of oxygen; RH strip indicates RH less than 10% (Photograph by Alice Boccia Paterakis)

3.2 COPPER ALLOY STABILIZATION PROJECT

A copper stabilization project was carried out by Stavroula Golfomitsou in 2000 and 2001. She treated bronzes from the Kaman excavation as well as new test coupons at the Institute of Archaeology in London. She tested benzotriazole (BTA), 2-amino-5-mercapto-1,3,4-thiadiazole (AMT), and 1-phenyl-5-mercapto-tetrazole (PMT) corrosion inhibitors, alone and in combination, on the Kaman bronzes. 22 test groups of 10 objects each were run, totaling 220 objects. She tested both water and ethanol as the solvent. The objects have been stored in closed Tupperware-like containers with silica gel (that was regenerated annually) in the Conservation Laboratory since 2000 (fig. 3).

Fig. 3. A few of the containers holding the bronzes treated with the corrosion inhibitors (Photograph by Alice Boccia Paterakis)

In 2008, after surveying all the bronzes treated by Stavroula Golfomitsou at Kaman, it was apparent that the most successful inhibition was provided by immersing the objects for one hour in a mixture of 0.1M BTA and 0.01M AMT (10:1 BTA: AMT) in ethanol in normal atmospheric conditions. For her test results on new copper alloy coupons from the Institute of Archaeology London, see Golfomitsou and Merkel 2007.

4. EXPANSION OF THE JAPANESE INSTITUTE OF ANATOLIAN ARCHAEOLOGY AT KAMAN

The Japanese Institute of Anatolian Archaeology has instigated an ambitious building project with the goal of creating an international center for the study of Anatolian archaeology (fig. 4). Two octagonal buildings will house the conservation lab, zooarchaeology lab, archaeobotany lab, offices, library, auditorium, meeting rooms, etc. The two long narrow structures on the left are the storage rooms for the collection. The residence hall is seen in the right foreground.

Fig. 4. Architectural model of the expanded Japanese Institute of Anatolian Archaeology at Kaman (Photograph by Alice Boccia Paterakis)

5. KAMAN MUSEUM

A museum is being constructed next to the new center that will house the most important artifacts from the Kaman-Kalehöyük excavation currently housed in the Kirşehir Museum, and those yet to be discovered. The new Kaman Museum has been designed to replicate the existing *tel*, or mound, from which all the artifacts were unearthed (fig. 5). The museum is scheduled to open to the public in July 2010. The funds for the construction of the Kaman museum were donated to the Turkish Ministry of Culture by the Japanese Institute of Anatolian Archaeology. The museum will be owned and operated by the Turkish Ministry of Culture who will take on full responsibility for the collection and maintenance of the museum.

Fig. 5. Architect's rendition of the new Kaman Museum that will house the collection from the Kaman-Kalehöyük excavation (Photograph by Alice Boccia Paterakis)

6. FUTURE CONSERVATION PROJECTS

In the summer of 2010 the Conservation Laboratory is planning to hold a workshop on Materials Characterization and Spot Testing to be presented by Nancy Odegaard and Scott Carrlee for archaeological conservators in Turkey. A symposium for archaeological conservators in Turkey is planned for the summer of 2011 at Kaman-Kalehöyük.

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SOURCES OF MATERIALS

RP System: Escal roll, RP-3A and RP-5A oxygen absorbers, oxygen indicators, sealing clips
Mitsubishi Gas Chemical America, Inc.
655 3rd Ave., New York, New York 10017
(212) 687-9030
http://www.mgc-a.com/

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TECHNOLOGY AS A TOOL FOR ARCHAEOLOGICAL RESEARCH AND ARTIFACT CONSERVATION

GRETCHEN ANDERSON AND GIOVANNA FREGNI

ABSTRACT

Advances in image and analysis technology have been an immense benefit to the field of museum conservation. X-ray Fluorescence, 3-D imaging and industrial X-ray/CT scans all provide data through minimally destructive and non-invasive analysis.

Recent research at the Science Museum of Minnesota utilized equipment including the Bodelin ProScope HR, the Leica Stereo Explorer, the Next Engine Desktop 3-D Scanner and CT scans provided by North Star Imaging, Inc. This technology not only provides the conservator with needed analysis of composition and detailed images of surface structure, but equipment such as the Next Engine scanner can create three-dimensional images of an artifact that can be viewed from a variety of angles and measured without further handling of the artifact. This technology creates virtual duplicates that can be shared, measured, and studied by other institutions, thus providing larger data samples for researchers and information for conservators without subjecting artifacts to risks through repeated handling.

1. INTRODUCTION

Keeping up with and gaining access to technological tools for analysis is a perennial problem. Not only is cutting edge technology expensive, but a certain level of expertise is required in order to obtain and interpret the data. The Conservation Department of the Science Museum of Minnesota (SMM) and the students at the Arch/Bio labs of the University of Minnesota (UM) found that they needed increasing amounts of technology in the course of work and research. For staff members who have not kept up with technological advances, the escalating innovations in technology can be intimidating. Many distinctly remember a time when computers were not a part of everyday life.

Technology for conservation and analysis is increasingly becoming more a part of the conservator's job. In recent years, a variety of techniques have been used to answer research questions as well as aid in collections conservation. Today more user friendly computer technology can be used to gather more data and share it.

In the course of the past few years, the Research and Collections Departments at SMM have utilized a number of techniques in order to improve care of collections and to answer research questions. However, the challenge is how to gain access to these technologies and still remain within a budget.

While the list is not exhaustive, the staff at SMM, with the help of partnerships, have been successful in utilizing several types of technology for research and collections management. Microscopic analysis included the Bodelin ProScope and digital microscopy. Three-dimensional imaging was used both in microscopic and macro formats. Research was also aided by X-ray and Computed Tomography (CT) scanning, and X-ray Fluorescence (XRF).

In the "old days" few conservation labs could afford the expense of such high tech equipment. Expenses included the initial purchase and maintenance of a specialized tool along with a technician to run it and to interpret the data. Most institutions were lucky if they had access to good quality cameras, specialty lighting (IR and UV), a computer, and maybe an x-ray. With the advent of more affordable computers, many conservators found themselves struggling to input raw data into computers running DOS and trying to retrieve usable information.

The technology was complicated and expensive. Budgets were (and are) constrained. Museum staff learned about technology out of necessity, often without formal training in the new resources. The more farsighted could see where the technology was going but it was not accessible yet – at least for the casual user. No wonder high tech analysis was used as a last resort.

Times have changed and specialist technical staff is no longer needed to run a computer or an SEM and interpret the data. While the equipment is still very expensive and might require some special training, there are ways to get around the problems of accessing the data and interpreting the analysis. Today, staff members are accustomed to working with computers. New user-friendly software makes the tools and analysis more intuitive and most proprietary software can be downloaded to programs we are familiar with, such as Excel.

2. THE RIGHT TOOL FOR THE RIGHT JOB

A single piece of technology, no matter how versatile, will not provide all the answers. Needed information about an object must be matched with the method. The first question should always be, "what do we need to know about this object?" The second will be how to decide which method works best for the desired output. Each technology has limitations. For example, some types of imaging equipment have limits on the size of object they can analyze, and some equipment requires training in order to understand the data. Using the equipment takes practice. In the case of the ProScope, it is very difficult to get a good image of an insect unless the operator has developed the skills in photographing three-dimensional objects with a limited depth of field. Museum staff will need to know enough about the technology to know if it will answer their questions. In addition, if it is necessary to work with an outside contractor or vendor for analysis, conservators will need to clearly explain their needs to that person. It is essential to be able to work with a technician who can provide the final data in a usable form. With the proper interpretation these technologies can provide insight into many aspects of an object.

3. ACCESSING THE TECHNOLOGY

The technologies being addressed in this paper include digital microscopy, CT scanning, 3-D imaging and 3-D printing. As always, there are numerous ways to gain access to these, depending on the cost and how integrated the technology is into the conservators' daily routine. Equipment, such as a digital microscope, can be purchased if it is not too expensive and will be used frequently. If funding is not available through operating funds, then grant funding or donations can be sought. The SMM conservation lab used IMLS CPS grant funding to purchase the first digital microscope and a budget surplus to purchase a ProScope. The expense can be justified because it is relatively reasonable and is used constantly for examination and analysis of the collections.

Another tried-and-true method is to develop partnerships with colleagues in other departments or institutions in order to share expertise and data. SMM's Departments of Archaeology and Conservation developed a close relationship with the UM Archaeology Department. One UM archaeologist, John Soderberg, was adept at 3-D imaging (both acquiring it and at producing top quality images). The author, Gretchen Anderson, took on one of Soderberg's students, Giovanna Fregni, and the imaging partnership began. During her internship, Fregni began researching early metalworking technology of the Minnesota Copper

Complex. While studying the museum's collection of spear points she realized that in order to examine use wear and accurately measure the collection, she would need equipment that would provide a better surface image as well as 3-D imaging that UM could provide. Arrangements were made to transport the artifacts to the university where 3-D images could be made and used for analysis (fig. 1).

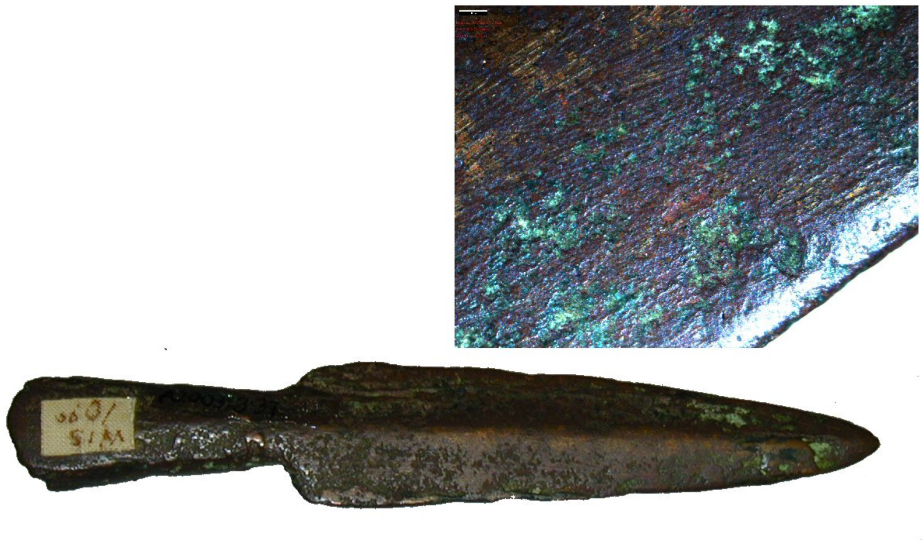

Fig. 1. Copper spear point (53-46) from the Science Museum of Minnesota with 3-D microphoto of surface showing wear (Photographs by G. Fregni)

Other strategies must be used for other pieces of equipment that are cost prohibitive, or too large and too complicated for the layperson to use. SMM paleontologist Bruce Erickson connected with North Star Imaging, Inc., a private company that does industrial scanning on engine parts, amongst other things. North Star was interested in expanding their services to museums and SMM was interested in finding out what was in the interior of a Late Jurassic/Early Cretaceous crocodile skull of the species *Goniopholis*. North Star Imaging scanned the specimen in exchange for experience and publicity. They were thrilled to work on something different than the usual fare (fig. 2).

Once an object has been imaged it can also be reproduced in 3-D. Three-dimensional printing technology is not terribly expensive or hard to get. And there are companies available for hire to produce these casts. This may be worth the investment if the object is needed for display or research and is too fragile to be handled.

4. WHAT CAN TECHNOLOGY PROVIDE?

Collections data can now be far more detailed and stored in far less space than ever before. Databases can hold complete descriptions along with photographs and links to the raw data of analysis as well as the interpretation. In addition, the artifact can be compared to the data to track any changes, such as deterioration or fading. By building a file of micro- and macro-photographs and creating 3-D images, the data can also be shared on websites or sent directly to other institutions. Online databanks, such as Britain's Archaeological Data Services provide an easy way to share data between field archaeologists, museums and researchers. Three-dimensional images can allow museums to share virtual copies of artifacts without having to remove the original from collections. The result is that researchers do not have to travel to access data about artifacts, and there is reduced handling of fragile objects.

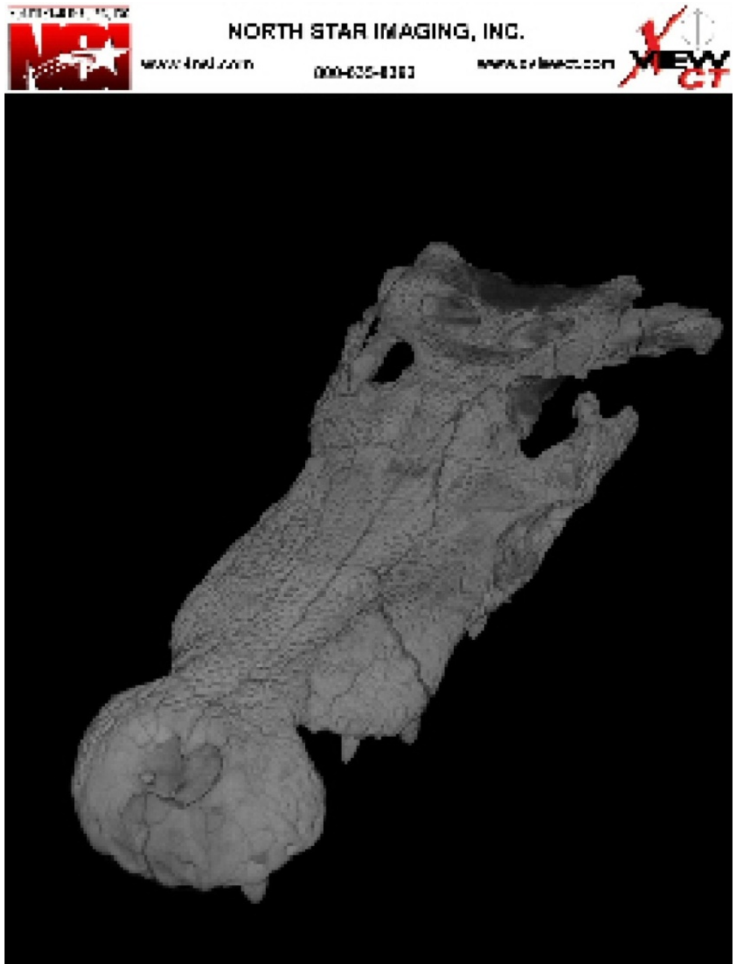

Fig. 2. CT image of *Goniopholis sp.* (Image courtesy North Star Imaging, Inc.)

5. MICROSCOPY

One of the most ubiquitous tools available to the conservator is the microscope. Members of conservation staff are comfortable working with dissecting microscopes adapted to be used with film and digital cameras. With the addition of a software program, they can be attached to monitors or projectors so that a group can see the images as well as being able to capture the images for the catalogue. The images are clear and help in the identification of materials, damage, and pests, and can also be shared amongst colleagues and used in teaching. However, microscopes do have their limitations, especially when the object is too large for the stand.

The SMM purchased and used two types of digital microscopes – both are affordable:

1. Intel QX3 / QX5: It is an educational toy, the modern version of the amateur microscope. It is light, portable and inexpensive, and costs under $100.00. The QX5 is compatible with both PC and Mac platforms. Magnification is at 10X, 60X and

200X, although the optics are not the best, particularly at the higher magnifications. However, they are adequate for pest identification and object examination. The unit is capable of both still and motion capture and can be hand-held or placed in its stand. It works with both transmitted light (for slides and transparent objects) and reflected light (for opaque objects, such as metals and minerals). The stand that was provided with the unit is clumsy to work with. However, a stand was easily built that provided better control for focusing. The Paleontology Department at SMM has used the QX3[1] extensively in the field to examine and document specimens and because the unit is so inexpensive there is no concern about it being damaged by dust or weather.

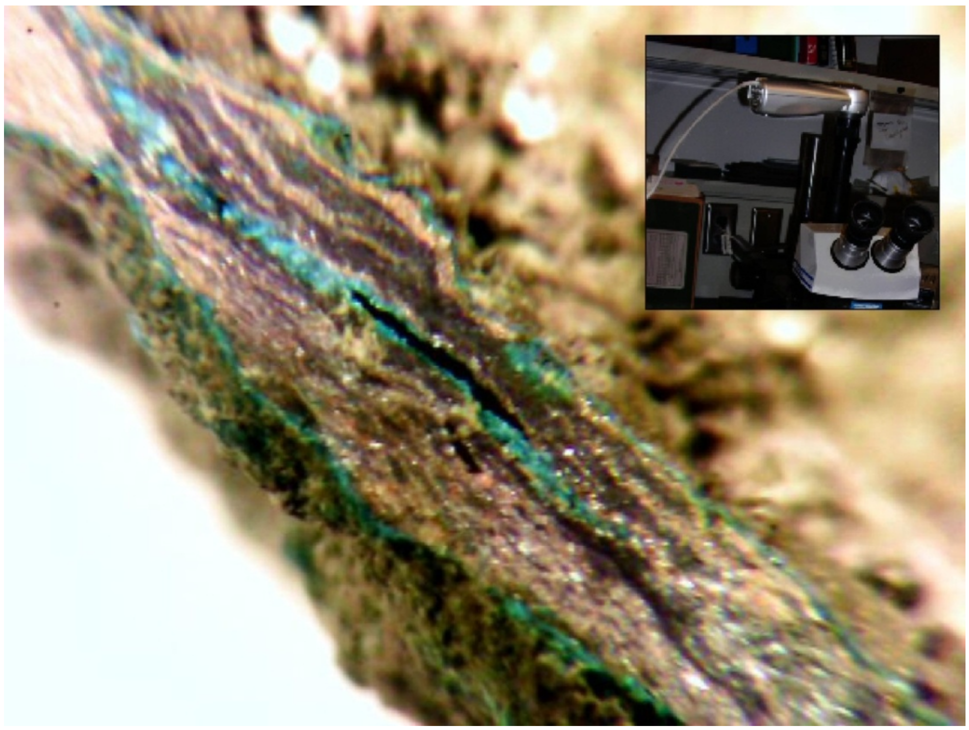

Fig. 3. ProScope and image of bronze artifact (A81:5:58) showing where carbonate corrosion has replaced metal (Photographs by G. Fregni)

2. The Bodelin ProScope HR CSI Science Level (fig. 3) is a handheld microscope that can be purchased for a relatively reasonable cost (under $600.00). The ProScope connects to a computer using a standard USB cable and can be used for both still shots and films. In addition, it can be mounted on a standard microscope and be used as a digital camera that downloads directly to the computer. The advantages are that it is portable, and is easy to use and share information. As mentioned above, the ProScope has a limited depth of field, however the range of lenses available (0-10X, 30X, 50X, 100X, 200X, 400X and 1000X) and its ease of use make it a valuable tool for detailed examination of artifact surfaces and pest identification.

6. FROM X-RAYS TO CT SCANS

3-D imaging is also becoming increasingly cheaper - what was $20,000 equipment four years ago now costs $3,000-4,000, including bundled software. Stereo microscopes such as the Leica

Stereo Explorer can be used to create 3-D microphotographs of artifacts. The software layers the images and then builds a 3-D computer model that is then draped with a "skin" that is formed from multiple two-dimensional color images of the object. The measurements are also embedded in the image. The resulting image can be rotated and examined from different angles, allowing the researcher to more easily see minute surface variations and textures. This technology is currently being used at the UM Anthropology Labs to examine cut marks on bone in fine detail. The SMM is also using this technology to examine cord mark decoration and building techniques in Woodland ceramics. The imaging process also aided in the author's (Fregni) research in Copper Complex metallurgy. By examining the surface she was better able to understand how copper spear points were manufactured and used.

X-ray and CT Scanning also are indicators as to how times have changed. Traditional X-rays "see through" the soft tissue and show the denser skeletal material. These images are very helpful diagnostic tools formed from static, single perspective views. However, CT uses X-rays but provides more data by taking 180-degree images of a body (or object) as it passes through the machine. The resulting images are printed as a series of slices. The technology was developed in the 1970s, with the first medical installation in the US at the Mayo Clinic in Minnesota. At that time all of the images were produced on film. Today the image is digital, making the data easier to reassemble and recreate as a three-dimensional image.

In 1980, archaeology curator Dr. Orrin Shane worked with a local hospital to run X-ray and CT scans on SMM's Egyptian mummy. A donor had acquired the mummy in the late 1920s and, as it had no provenience, there were concerns about its authenticity. When the museum constructed a new building, the mummy was to be reinstalled in a new case. These events created an opportunity to answer the authenticity question. At that time, Minnesota was on the cutting edge of CT scanning – it was the new, exciting diagnostic tool for medical research. Since SMM was connected by skyway to St. Joseph's Hospital, the mummy was placed on a gurney and wheeled across the skyway to the new X-ray and CT Center. The relationship was beneficial to both the hospital and to SMM. The hospital learned innovative uses for its new piece of equipment and gave SMM the X-ray along with a few diagnostic scans that proved that the mummy was authentic. The key image of SMM's mummy CT scan is a slice through the skull. According to the ancient Egyptian methods of mummification, the brain was removed with a hook or spoon inserted through the nose. To do this, the septum (the bone supporting the nose) was broken, and in the image the septum is clearly broken. Fake mummies do not have this feature. The traditional X-ray of that area does not show this view of the septum, where the CT scan provides a positive identification for the mummy's authenticity (figs. 4-5).

Today, CT scans have many more uses than medical diagnosis and authenticating mummies. Industry uses the technology to look for imperfections and defects in any kind of manufactured item – everything from widgets to engines and every material from plastics to steel.

There are two primary methods of scanning: linear and conical. With a linear scan, the x-ray slices the object into minute sections – like a loaf of bread. The object is placed on a platform as a machine passes over, taking images one slice at a time. Each slice is made of images rotating 180 degrees. The intervals from which the data is taken can be adjusted, much like changing the thickness of the slicer on a bread slicing machine.

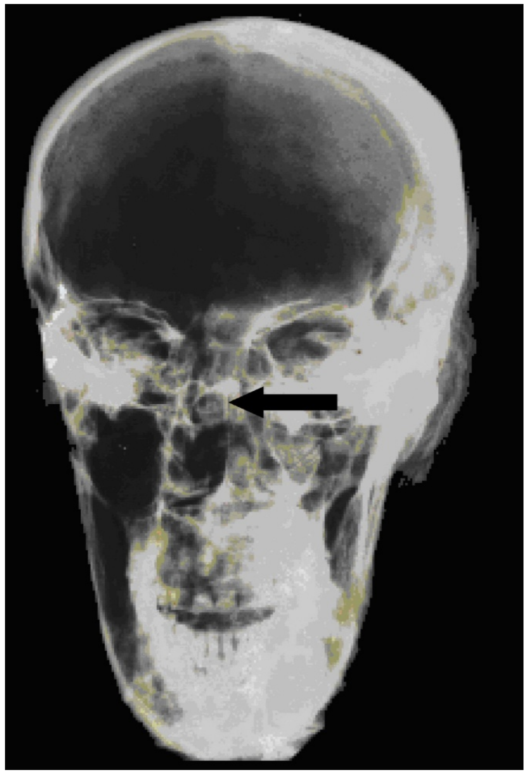

Fig. 4. X-ray scan of mummy (1-1514) showing septum (arrow)
(Image courtesy Research and Collections Division of the Science Museum of Minnesota)

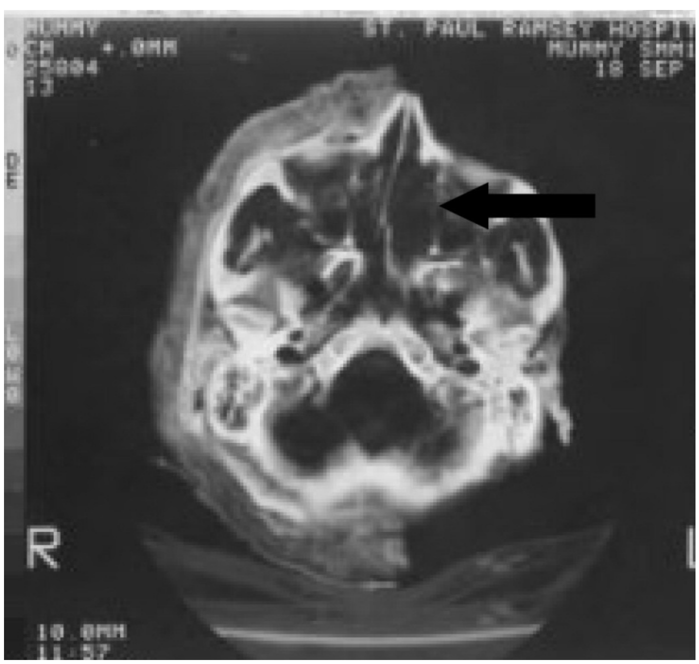

Fig. 5. CT scan of mummy (1-1514) arrow indicating broken septum (X-ray by St. Joseph's Hospital, St. Paul, MN; image courtesy Research and Collections Division of the Science Museum of Minnesota)

In the second method, data is gathered by subjecting the object to a cone of radiation. The object is set on a rotating platform. This method provides less data, but still yields a wealth of information. In both cases, all of the data is interpreted through the software and 3-D images are built up that can be rotated and viewed from every angle.

However, it is important to remember that CT scans will expose the object to radiation. The amount of radiation is determined by the strength and frequency of the sampling rate, as well as by the method. Medical CT scanners use less radiation and accumulate less data. They are set for the levels of radiation that can be "safely" tolerated by the human body. Industrial scanners do not have those limitations and can penetrate denser objects.

Done properly, different materials constituting the object can be identified. Objects can also be reassembled in three dimensions and the "skin" can be applied.

SMM has been working with an industrial imaging company, North Star Imaging, to examine a crocodile skull (*Goniopholis sp.*). The imaging equipment they used gathered data using a cone spread of radiation. The skull was set up on the platform at the *foramen magnum* (the area where the spine attaches to the skull), so that the snout was pointed straight up. The platform rotated and three sections were scanned –the snout, the middle area and the base. The data was manipulated and the three separate scans were stitched together into a single, seamless image. The detail was astounding. The senior paleontologist was able to see internal structures that had never been visible before (fig. 6).

This technology goes far beyond a simple x-ray. Its greatest advantage is that the inside of objects and specimens can be examined without opening or compromising their integrity. Moreover, this technology can provide much more information, including distinguishing different densities in materials – down to the level at which tree rings can be read. Applied uses can include identifying construction techniques, identifying different materials used in construction, identifying old repairs (both legitimate and non-legitimate) and authenticating artifacts. With *Goniopholis sp.* the difference between the actual fossil and matrix could be differentiated for the first time.

7. 3-D SURFACE SCANS

For surface analysis, 3-D scanners have a variety of uses. While some are large enough to handle dinosaurs, others are portable tabletop units. The smaller scanners, like the Next Engine Desktop 3-D Scanner can be used to create 3-D images that can be viewed individually or combined into films in which an object can be manipulated and seen from different angles (fig. 7). In this case, the author (Fregni) made scans of several copper spear points to take multiple measurements of angles to compare them, all being done with minimal handling of the artifacts. Once the 3-D image was made, the software was used to take multiple measurements and calculations that were then downloaded into a spreadsheet. The digital images allowed far more accurate measurements to be taken and allowed direct comparisons to be made, both visually and numerically. By making these images available to others, the images can be added to databases in order to create a larger sampling base. Other researchers will be able to use the same 3-D images to answer their own questions without having to travel to the institution.

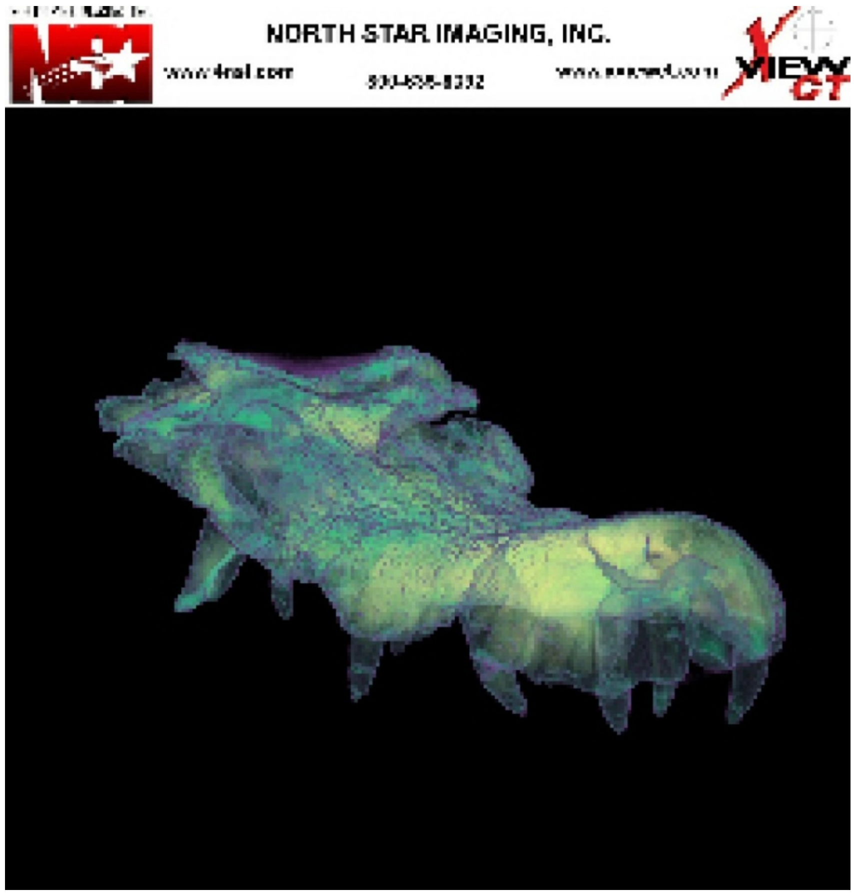

Fig. 6. *Goniopholis sp.* (Image courtesy North Star Imaging, Inc.)

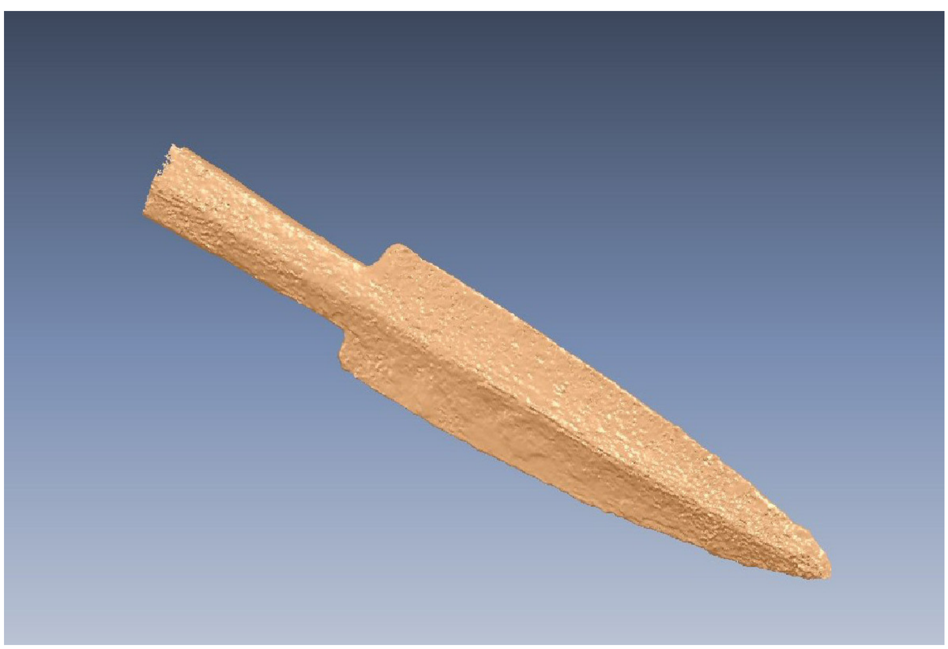

Fig. 5. 3-D image of copper spear point (53-46) from Science Museum of Minnesota collection made using tabletop scanner (Image by G. Fregni at the University of Minnesota Arch/Bio Lab)

8. MAKING 3-D IMAGES THREE-DIMENSIONAL

Any object that can be imaged in 3-D can also be replicated in a 3-D printer. By using computer assisted design (CAD) technology, an exact 3-D duplicate can be made of the original in a variety of materials. Three-dimensional prints are made in several different ways, either by building up layers of plastic to re-produce the object or by triangulating a laser into a substance that fuses the material in order to form the image.

Fig. 6. *Rapetosaurus krausei* skull (Photograph by Rebecca Newberry, Science Museum of Minnesota)

These scanners can be used to replicate missing parts, or replicate objects too fragile for more traditional methods of casting. They can also be used to resize objects enabling more refined research. Kristi Curry Rogers, one of SMM's paleontology curators at the time, was working on a particularly fragile specimen, the skull of a juvenile *Rapetasaurus* (Rogers and Foster 2004) (fig. 8). It was a key specimen in her research and an important specimen for display. The skull was too fragile to handle, much less to be mounted for exhibition. In addition, there were missing parts. The skull was carefully packed and sent to Research Casting International in Trenton, Ontario for scanning and casting. Detailed scans were made using CAD, drawings were completed and a model was printed in 3-D (fig. 9). Since there were many losses, as is common with paleontological specimens, the missing pieces were filled in by a combination of sculpting missing parts and scanning other specimens. These parts were then scaled to match the size of the original specimen. If the right bone was missing, but the identical left one was present, a mirror image could be reproduced (fig. 10). Rogers requested that some of the minute structures from inside the skull be enlarged so that she could easily see how they fit together. In this way the specimen was better understood, and more accurately assembled. The original material is still too fragile to handle or mount, however the 3-D model is now on display at the Field Museum.

Fig. 9. 3-D print of *Rapetosaurus krausei* skull created by Research Casting International (Photograph by Research Casting International)

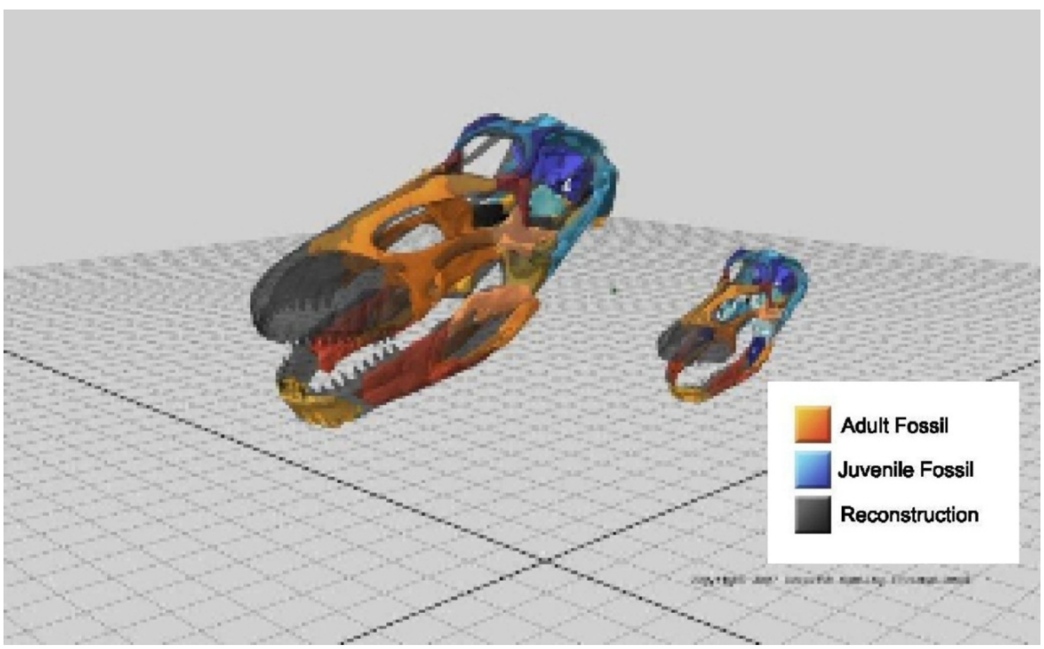

Fig. 10. CAD drawing of *Rapetosaurus* skull showing how parts were used from adult and juvenile skulls to create a completed model (Image by Research Casting International)

9. CHEMICAL ANALYSIS

X-ray Fluorescence (XRF) analysis is another tool that is becoming more affordable. The portable machine is easy to use and the data downloads into Excel (fig. 11). XRF gives a detailed list of the elemental characteristics of an artifact. This not only helps in research and analysis, but has also been used in conservation to identify toxins and other materials. The XRF bombards a minute area of the surface of the artifact with x-rays, penetrating less than a millimeter below the surface. The electrons absorb the radiation, causing a disruption in which the electron moves up to the next orbit. As the energy dissipates, the electron moves back to its original orbit. This rate of energy exchange is unique to every element and is used by the XRF to identify the individual elements within an object. Readings can be taken quickly and work can be done either in the lab or in the field. While XRF is an excellent tool for analyzing heavier elements, lighter elements can be difficult to determine with some models. It also is difficult to distinguish between metals and oxides. However, this can be compensated by complementing XRF with visual analysis or with a more complete understanding of the raw data (Ketcham and Carlson 2001).

While XRF is described as being non-destructive and non-invasive, there are materials that can be damaged through prolonged exposure (Mantler and Klikovits 2004; Garside and O'Connor 2007). Fibers and wood are especially susceptible to desiccation or burning caused by the radiation. This is a consideration when XRF is used to analyze the chemical make-up of pigments used in paintings, on paper, or on fibers.

However, as with any form of technology, care must be taken to understand the results. Interpretation requires an understanding of the limitations of the technology as well as knowing how to work with the raw data. Chemical readings from XRF will sometimes overlap and create a false peak. By learning the different ways in which data can be viewed, the conservator will be able to use a powerful tool that can not only provide information about the make-up of inorganic artifacts, but will also be able to immediate identify toxins on the surface of the object.

Fig. 11. G. Fregni using XRF at University of Sheffield (Photograph by Homa Badr)

10. THE BOTTOM LINE

But all of this does cost money. The question remains: how to get access to expensive technology?

First, it is important to determine what technological medium would be advantageous to own. A priority list should be made with the main criteria for equipment that will be frequently and easily used (i.e. software that makes data gathering and analysis reasonable). Just as computers have now replaced typewriters, film cameras and microscopes have improved and are able to expand capabilities that combine with current digital equipment.

The next step is to create strategies for purchasing by building the priority into the department or lab budget. Larger institutions can look into a partnership with other departments and share expenses. Other familiar avenues include writing grant proposals or looking for donors. Finally, purchasing used equipment or older models is always a viable option. However, it is important to ensure that the model will provide the necessary information and will interface with the existing technology.

However, owning a piece of equipment might not be an option. This could be due to budget constraints or lack of physical space. This is where community partnerships are useful. Cooperation between UM and SMM has been beneficial, as has SMM's relationship with North Star Imaging. In partnering with North Star Imaging, SMM was able to have highly specialized work done, and North Star Imaging was able to demonstrate new applications for their technology.

SMM's experience with the mummy showed that some of these companies want to use their expertise on something more interesting than engine parts, or try out new equipment. It is advantageous to partner with an organization that has the equipment already and a staff that knows how to use it. In the earlier example of SMM's partnership with North Star Imaging, the museum found that North Star wanted to expand their market and needed examples to sell their product. By agreeing to allow North Star Imaging to use the images, SMM was able to have the scanning done for free.

Sales representatives can also be a resource. They can assess whether or not a piece of equipment will be appropriate. If the equipment is portable, they might bring it to you, or as in the case with North Star Imaging, the artifact was brought to the company. Businesses will frequently loan equipment to an institution in order to understand if it is the right technology for the institution's needs.

11. CONCLUSION

Conservators are accustomed to adapting tools originally designed for other purposes, such as examination and treatment. The creative use of high-tech equipment is simply another form of this action. The good news is that the technology is becoming more user-friendly and more affordable! It is the conservator's job to know what is available that can be used effectively in examining and understanding the objects being cared for.

The personal computer was introduced over 20 years ago. Many conservators struggled with the primitive programming in attempts to wrench out useful reports and databases. Today there is hardly a lab without a computer. The technology has become easy to use and affordable. The same phenomenon is happening in other types of technology. Digital cameras have become ubiquitous. Digital microscopes such as the ProScope and the QX5 are now affordable and easy to use (the QX5 is now marketed as a child's toy). 3-D digital imaging can be done easily and for the cost of what a high-quality film camera used to cost. There are companies who can provide their services with medical and industrial CT scanning for in-depth analysis of materials and structures. Other companies can use this data to produce casts of artifacts or specimens without putting the object through the strain of mold making. Equipment such as the portable XRF is becoming easier to use and interpret chemical analysis. Industrial scanning is also a great resource; it can measure density and see inside the object. Each tool has its own niche and can answer specific questions. The important point is to know the questions that need to be assessed and how available technology can answer those questions.

In short there are many high tech tools that can be used to enhance the conservators work. He or she must be an informed consumer.

1. Determine the right tool for the job. Understand what research question is needed, and what it will take to get the answer. Decide if the cost of the technology is worth the financial and time commitment.
2. Seek partnerships with other organizations or with vendors to use the equipment.

The 21st century is upon us. Embrace it.

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NOTE

1. Anatomy of the QX3 microscope
http://micro.magnet.fsu.edu/optics/intelplay/intelanatomy.html

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