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PREFACE

The 26th volume of POSTPRINTS contains papers presented at the textile sessions of the American Institute for Conservation of Historic and Artistic Works (AIC) and the Canadian Association for Conservation (Association canadienne pour la conservation et la restauration) (CAC-ACCR)'s joint 44th Annual Meeting and 42nd Annual Conference in Montreal, Quebec, Canada in May, 2016.

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DISSOCIATION RISKS: THE CONSERVATION OF TWO ABORIGINAL FIGURINES AND THEIR TEXTILES

NICOLE CHARLEY AND JEAN DENDY

ABSTRACT—This article discusses the conservation treatment of fragile tunics worn by two 19th century Huron or Wendat figurines. Consolidation via ultrasonic misting was investigated for the tunic on the first figurine. Though examples of this treatment method used on textiles were not encountered in the literature, with the encouragement and collaboration of colleagues from other disciplines, a number of consolidants in aqueous solutions were tested. A treatment protocol using a 0.25% w/v solution of Aquazol 200/Methocel A15C in a 1:1 ratio was developed. The treatment of the second figurine used what was initially designed to be a temporary facing method—a homemade pressure-sensitive tape of Hollytex coated with Lascaux 360HV adhesive—as a permanent backing and mending tissue. The final part of the article discusses an important conservation issue: risk of dissociation of Aboriginal objects from their cultural context is increased in museum collections. Conservators have a responsibility to contribute as much as possible to the history and identification of these objects through current analytical methods, treatment, and documentation practices.

RESUMEN—Este artículo discute el tratamiento de conservación de las túnicas frágiles de dos figuritas Huron o Wendat del siglo XIX. Se investigó la consolidación por nebulización ultrasónica para la túnica de la primera figurita. Aunque en la literatura no se encontraron ejemplos de este método de tratamiento utilizado con textiles, con el apoyo y la colaboración de colegas de otras disciplinas, se probaron varios adhesivos en soluciones acuosas. Se desarrolló un protocolo de tratamiento utilizando una solución al 0,25% p/v de Aquazol 200/Methocel A15C en una relación 1:1. El tratamiento de la segunda figurita usó lo que inicialmente fue diseñado como un método de enfrentamiento temporal—una cinta adhesiva casera de Hollytex con el adhesivo Lascaux 360HV—como un material permanente de refuerzo y reparación. La parte final del artículo discute un importante problema de conservación: el riesgo de disociación de los objetos aborígenes de su contexto cultural aumenta en las colecciones de museos. Los conservadores tienen la responsabilidad de contribuir tanto como sea posible a la historia e identificación de estos objetos a través de los métodos analíticos actuales, el tratamiento y las prácticas de documentación.

1. INTRODUCTION

In 2006, the Musée de la Civilisation in Québec City acquired a set of rare Aboriginal figurines. The treatment of two of these figurines, numbers 2006.413 and 2006.414, will be discussed. The figurines will be referred to by their abbreviated accession numbers, 413 and 414. The article will also discuss the “dissociation risks” from cultural contexts that First Nations objects, such as these figurines, are facing in museum collections.

Both figurines (fig. 1) are constructed with heads and torsos roughly carved from a single piece of wood. The arms and legs are articulated at the shoulders and hips. Both figurines have metal armbands and metal headbands. The tops of the heads are cut flat, and remnants of feathers can still be observed there. Simple facial features are carved and then painted; the backs of the heads are also painted in black, presumably to represent hair. Both figurines are adorned in untanned leather moccasins and woolen leggings. Simple tunics complete the outfits—unbleached cotton tabby for figurine 413, while figurine 414's is of printed cotton. The cords tied around the waist of each figurine are not thought to be original.

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Fig. 1. Left: figurine 414, and right: figurine 413, before treatment.

There is very little historical information extant for these figurines. It was believed that they might have been made to represent two Huron-Wendat individuals newly converted to the Catholic Church by Jesuit missionaries.

2. ANALYSES

In an attempt to identify the metals used, the headband on figurine 414 was analyzed using a portable Innov-X Model 440 ED-XRF spectrometer (Moyle 2014). Since the surface area of the band was so small, it was difficult to definitively quantify the metals present. According to the results, the analyzed metal is mostly iron with trace quantities of tin and lead, which indicates either tinned sheet iron (in this case, the lead present would likely have been used as a soldering or brazing material), or terne sheet (iron plated with lead-tin alloy).

X-radiography revealed the presence of radiopaque pigments, likely lead-based, on the lips of both figurines and on the cheeks of figurine 413.

Dyes and mordants from the printed tunic and leggings of figurine 414 were analyzed by GC-MS, Raman spectroscopy, FT-IR, polarized light microscopy, and SEM/EDS (Poulin 2012). Raman spectroscopy revealed the presence of chrome yellow in the tunic. Chrome yellow was not commercially available before 1815 as a pigment (Kühn and Curran 1986) and 1830–1840 as a dye (Liles 1990; Adrosko 2012). In light of this, coupled with the results of the metal analyses as well as historical research by the museum's curator, it was concluded that it is unlikely that figurine 414 (and therefore its twin, 413) predates the mid-19th century.

3. TREATMENT

3.1. METALS AND WOOD

The metals and wood were lightly cleaned using typical mechanical methods. Dusting revealed the radiopaque pigments detected by the x-rays: red pigments on the lips of both figurines and white lines on the cheeks of figurine 414 (figs. 2, 3).

3.2. TEXTILES

The initial proposal precluded treatment of the textiles because access to the verso of the tiny tunics was quite limited. There was also concern that treating the textiles might do more harm than good. This was especially the case for figurine 413, whose tunic exhibited marked loss and degradation. In addition, since these artifacts were destined to be study pieces, it was desirable for them to remain as untouched as possible.

3.2.1. Figurine 413

As treatment on the metal and wooden components progressed, it soon became clear that treating the textiles would be unavoidable. 413's tunic was progressively degrading, even with careful manipulation, and each time the figurine was moved there was additional loss of textile fragments and fibers.



Fig. 2. Detail of head of figurine 413, left: before treatment, and right: after treatment.

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Fig. 3. Detail of head of figurine 414, left: before treatment, and right: after treatment.

Consolidation via nebulization, or ultrasonic misting, was investigated. This involves the application of successive layers of very dilute concentrations of consolidant dispersed in a fine mist created by an ultrasonic nebulizer. This technique has been used with a great deal of success to consolidate powdery paint on various substrates, as well as to consolidate paper artifacts and various organic archeological objects. Textile treatments have generally been limited to controlled bleaching and spot cleaning. To the authors' knowledge, consolidation via misting has not yet been applied to fragile textiles themselves. However, since the tunic was essentially a very soiled, dry, friable, and highly fragmented cellulosic material, it would presumably be possible to treat it like fragile paper or an object made of plant materials.

3.2.1.1. Choosing the Consolidants

The consolidants were selected following a comprehensive literature review, as well as consultation with various colleagues. Table 1 outlines the list of consolidants tested as well as the results of testing.

3.2.1.2. Testing the Consolidants

The ultrasonic mister used was an AGS2000 Aerosol Generator. Unbleached tabby-weave cotton recovered from a previous upholstery project at the Centre de Conservation du Québec was used for the mock-ups. Although neither as fine nor as fragile as the tunic, it was a naturally aged, stained fabric.

Table 1: Consolidants Tested and Results

Consolidant	Concentration	Solvent	Tide line	Mist	Notes
Klucel G	0.5% w/v	deionized water	Slight tide line in preliminary test	Some difficulty misting at low settings	
	0.5% w/v	ethanol	n/a	Did not mist	
	0.2% w/v	ethanol	Unable to determine	Extremely difficult to mist	Suggested concentration in operating manual. Added following failure to mist at higher concentration.
	0.5% w/v	water:ethanol (3:2) water:ethanol (4:2) water:ethanol (5:2)	Unable to determine	Extremely difficult to mist	
	0.25% w/v	deionized water	Slight tide line after fourth application in preliminary test	Consistent mist control of volume output	Good
Aquazol 200	0.25% w/v	ethanol	Unable to determine	Extremely difficult to mist	
Aquazol 500	0.25% w/v	deionized water	Tide lines after 1-2 applications in preliminary test. Less noticeable in second round of tests.	Consistent mist	

(Continued)

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Table 1: Consolidants Tested and Results (*continued*)

Consolidant	Concentration	Solvent	Tide line	Mist	Notes
Methocel A15C	0.25% w/v	deionized water	No tide lines detected	Consistent mist control of volume output	Good
Gelatin 225 Bloom	0.5% w/v	deionized water	Significant tide lines	Mists very easily but more difficult to control as a result	Discarded after first round of tests
Aquazol 200:Methocel A15C (3:1)	0.25% w/v	deionized water	Significant tide lines	Consistent mist control of volume output	Added in second round of tests
Aquazol 200:Methocel A15C (1:1)	0.25% w/v	deionized water	No tide lines detected	Consistent mist control of volume output	Added in second round of tests
Aquazol 200:Methocel A15C (1:3)	0.25% w/v	deionized water	No tide lines detected	Consistent mist control of volume output	Added in second round of tests
Hydroxymethyl propylcellulose: Aquazol 500 (95:5)	0.5% w/v	deionized water	Unable to determine	Did not mist at this concentration	Suggested addition in second round of tests (Pouliot 2015)
Deionized water	n/a	n/a	Significant tide lines		Used in first round to establish basic application method

Preliminary testing was performed in order to get a sense of the mister and of how each consolidant would react on the textile. In defined squares on the test fabric, three to eight applications of each consolidant (depending on its behavior) were made. Each application fully saturated the defined area and was allowed to air dry before subsequent applications. All detectable changes to the fabric were noted, including, but not limited to feel, tidelines, darkening, and yellowing.

In many publications, objects were placed in humidification chambers before consolidation, but since these figurines were composed of textiles, wood, skin, and metals, global pre-humidification was deemed inappropriate. Nonetheless, preliminary trials on the mock-ups were performed to try to determine how locally pre-humidifying the test areas might affect the subsequent application of consolidant. It was found that pre-humidification made it more difficult to determine where the nebulizer had passed and how consistently the consolidant had been applied. Pre-humidification also caused an increase in both the number and severity of tidelines as well as a slightly shinier surface after consolidation. Pre-humidification was therefore abandoned.

The consolidants selected for the second round of tests were based on the outcomes of this first series. The fabric for the mock-ups was divided into columns of approximately the same width, with one column per consolidant. Each column was further divided into up to eight equal rectangles (fig. 4). The total number of applications in each rectangle was incrementally increased from one at the very top of the column to eight at the very bottom. More subtle differences, if any, would hopefully become evident moving down the column.



Fig. 4. Preparation method of the mock-ups for the second round of testing.

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3.2.1.3. Results and Discussion

The results of the tests are summarized in table 1.

Though a nebulizer is typically used for localized and controlled applications of consolidants, the authors were pleasantly surprised at the amount of control achieved. It was possible to follow along a single warp or weft, and in most cases no tidelines were created even though with each application, there was saturation of the textile from front to back.

Unfortunately, some of the problems encountered were due to the mister itself. For reasons unknown, it sometimes simply refused to generate mist. It was also difficult to consistently nebulize consolidants in ethanol, or even in mixtures of ethanol and deionized water, regardless of concentration.

Gelatin 225 Bloom was discarded after preliminary tests as it had the greatest tendency to cause tidelines, as well as to darken (Dignard et al. 1997). Funori and JunFunori had also been considered, but due to the authors' lack of familiarity with these consolidants, as well as reported stability issues (Michel 2001), they were rejected before initial testing began.

0.25% solutions of 1:1 and 1:3 Aquazol 200/Methocel A15C gave the most satisfactory results. The 1:1 solution was deemed a slightly better combination of strength and flexibility. Both misted consistently and left no tidelines on the mock-up.

3.2.1.4. Consolidation Treatment

Small, manageable sections of the textile were consolidated, using existing seams to help define the areas to be treated (fig. 5). Generally, three to four saturated applications were made, with time to air dry between



Fig. 5. Consolidating the tunic of figurine 413 with the AGS 2000 aerosol generator.



Fig. 6. Protecting vulnerable areas with Mylar or Dartek during application of consolidant.



Fig. 7. Reshaping after application of consolidant using strips of Hollytex (a fine, smooth, non-woven polyester fabric).

applications. Four hours was considered ample time for air drying. Often two applications seemed sufficient; however, a third layer was applied for “good luck.” Wood and metal elements were protected with Mylar or Dartek during consolidation (fig. 6).

Consolidation treatment had the added benefit of allowing for controlled reshaping of the fabric when desired. Strips of Hollytex, Dartek, or nylon net spanning the treated area were either gently pinned down into the bed of Hollytex-covered cotton wadding that had been placed under the figurine, or clipped to the side of the box containing the wadding (fig. 7). Nylon net was particularly useful because recalcitrant fibers could be realigned through the holes with a slightly blunted fine probe (fig. 8).

3.2.1.5. Joining Detached Fragments

Detached fragments were reintegrated using 5g Japanese Tengujo paper coated with 2% w/v Methocel A15C in deionized water, applied to the verso of the tunic and reactivated by very light humidification. The paper was tinted with acrylic paints prior to coating and application. “Micro-patches” measuring roughly 1 cm x 1 cm were applied to further consolidate some of the more vulnerable edges. Finally, the few small areas of loss where the Methocel-coated paper was visible (causing a slight shininess) were retouched with ground CarbOthello pastel pencil in 5% w/v Laropal A 81 in ethanol (figs. 9, 10).

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Fig. 8. Reshaping after application of consolidant. Using nylon net allows for the realignment of fibers with a slightly blunted fine-tip probe.



Fig. 9. Figurine 413, recto, left: before treatment, and right: after treatment.



Fig. 10. Figurine 413, verso, left: before treatment, and right: after treatment.

3.2.1.6. Conclusion

After treatment of figurine 413's tunic, no added shininess or perceptible changes in color were observed. Most importantly, the textile is no longer friable and powdery. Though there may eventually be loss in areas such as the shoulders that were not possible to back with paper patches, the textile seems much stronger than before. Overall, there is a slight loss in the flexibility of the textile components, which is not unexpected after consolidation, but the tunic can be gently handled without falling apart, and the texture of the fabric seems unchanged.

3.2.2. Figurine 414

The tunic on figurine 414 did not present the same problem as that of 413. Though it was beginning to fragment, the printed tabby-weave cotton fabric was not powdery. The textile was quite stiff and did not relax with humidification. In fact, though prolonged humidification or wetting solubilized the print layer, the textile itself barely reacted at all, which made it impossible to reshape and difficult to realign the tears.

Once again, more traditional methods of textile conservation using needle and thread would not be possible on this object. Following an article on the use of temporary facings to line a shroud (Cruickshank et al. 1999), this method was investigated as a way to realign the tears from the outside, and hopefully facilitate backing and consolidation from the verso of the textile. A home-made pressure-sensitive tape also seemed like a good choice because it would eliminate the need for reactivation of the facing adhesive and allow for controlled realignment of the tears.

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Fig. 11. Using mock-ups to develop a method to temporarily face the tunic on Figurine 414.

3.2.2.1. Step 1: Developing a Facing Technique

Before selecting a final adhesive, the feasibility of using a pressure-sensitive facing was tested. Since it was readily available in the textile lab, initial trials were done using Lascaux 360 HV, an acrylic adhesive known for its tackiness. Solutions of 1:2, 1:1, and 2:1 Lascaux:deionized water were applied to Hollytex taped to Mylar. The 1:1 solution was selected as most appropriate.

Next, a successful application technique needed to be developed. The adhesive-coated Hollytex was cut into thin strips and applied using long-handled and stamp tweezers to increasingly complicated tears on mock-ups (fig. 11).

3.2.2.2. Step 2: Developing a Backing Protocol

The following step was to test how well the facing strips could be combined with a backing technique. Again, at this stage, the goal was simply to determine if a successful application protocol could be developed given the constraints of the object.

The mock-ups faced with the technique elaborated in step 1 were backed with 5g Tengujo paper coated with 15% w/v Aquazol 200 (table 2). The backings were reactivated using a damp blotter through a Gore-Tex barrier. It was found that longer reactivation times caused the pressure-sensitive strips used for the facings to fail.

Table 2. Preliminary Testing of Possible Backings in Combination with the
Elaborated Facing Technique

5g Tengujo paper coated with 15% w/v Aquazol 200	Reactivation times		
	10 min	5 min	2 min
1 coat	Facing released	Facing released	Facing still adhered
	Backing failed	Backing failed or tenuous	Backing failed
2 coats	n/a	Facing released	Facing still adhered
		Backing tenuous	Backing successful or tenuous

3.2.2.3. Facing as Backing

Concurrently with step 2, a facing test was conducted on Figurine 414's tunic using two Lascaux-coated strips. The strips were removed by applying toluene with a fine brush (fig. 12). However, given the water sensitivity revealed by the tests in step 2, the technique began to evolve in a different direction. The test was repeated, but this time, the strips were removed with deionized water applied with a fine-tipped brush. A full mend was tried on the tunic (fig. 13), but the project was then interrupted for a few years. After this time, the facing was still easily reversible through the application of water (and would also presumably be reversible using humidification as tried in step 2).

Given these results, it was decided to attempt to use the technique intended for the facing as a backing instead. This method could be used to gradually realign the threads and mend the tears; the pressure-sensitive strips could be repositioned if needed, required no reactivation, were sufficiently strong to form a good bond, and were fully reversible with the application of deionized water, thus avoiding the use of a toxic solvent.

3.2.2.4. Figurine 414—Consolidation Treatment

The Lascaux-coated Hollytex strips were thus repurposed as a backing. Since it was impossible to see the verso of the tunic during treatment, it was difficult at first to be sure that the strips were properly aligned with the tear, but the technique improved with practice. Each strip was first perpendicularly aligned to the tip of the long-handled tweezers, which were then used as the point of reference when aligning the strip with the tear. The stamp tweezers were used to apply the necessary light pressure to affix the mending strips, which were also very slightly overlapped to give a more continuous support and completely fill in the gaps.



Fig. 12. Mending test on figurine 414. Two strips of the adhesive-coated Hollytex were applied on a tear.

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Fig. 13. Testing a full mend on figurine 414.

The Hollytex was pre-tinted with CarbOthello pencil so it would be less noticeable in areas of loss. The few exposed areas were then lightly retouched to reduce shininess and tack (figs. 14, 15), with ground CarbOthello pencil colors mixed with 10% Regalrez in ethanol.

3.2.2.5. Conclusion

The treatment for figurine 414 was much less complicated than expected and gave an extremely satisfying result. One of the concerns with using un-reactivated Lascaux is possible migration onto the textile. Though this possibility was considered, it is believed that the museum storage environment for the figurines is sufficiently stable. These objects can be monitored and the backing can be easily released if the adhesive begins to show signs of migration in the future. Overall, the benefits of using consolidation to permit handling and future study of these figurines outweigh the potential risks involved in the treatment.

4. DISSOCIATION

If one considers that treatments should be in response to the most critical agents of deterioration facing an object, then there is still much work to be done on these figurines. One of the agents of deterioration that threatens them the most is dissociation, but a certain kind of dissociation that puts Aboriginal objects at risk more than others.

4.1. AMBIGUOUS TITLES

The first issue is with the name and description of the objects. They were assigned the ambiguous title “Figurine Amerindienne, terre boisé du nord.” This translates to “North American Indian, northern



Fig. 14. Figurine 414, recto, left: before treatment, and right: after treatment.

woodlands,” a title that would keep the figurines in obscurity from people who might search for objects that represent the material cultural heritage of Wendat people today. In May 2013, at a session on repatriation and restitution of Aboriginal objects in museum collections presented at the ACFAS (Association Francophone pour le Savoir) conference, Bibiane Courtois, former director of the Innu museum in Mashteuiatsh, Québec, expressed that she believed one of the greatest problems between museums and Aboriginal communities in Canada is that Aboriginal groups do not know what objects from their cultures exist in museum collections. Using these figurines as an example, they have never been put on display, so unless someone were invited to view the objects in storage, they would never be seen. The objects are not part of the museum’s digital online collection, and even if they were, the researcher would have to know to search for “Northern woodlands” objects instead of Huron or Wendat or Wyandotte or even Iroquois (which is the linguistic group that the Wendat belong to).

Titles like these almost seem like they are designed to keep the objects in obscurity. When the authors have asked curators the reason why museums do this, the answers given have been:

- To protect the researcher’s work or because the research on the object is incomplete, so releasing it to the public would be premature.
- The institution would like to avoid getting competing repatriation claims from multiple groups who might each have a legitimate claim on the object.
- Because assigning overly precise labels may be reductive and possibly inaccurate.

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Fig. 15. Figurine 414, verso, left: before treatment, and right: after treatment.

In response to this reasoning, a more appropriate approach would be that, in cases where complexity exists, it should be explained to the best of our current understanding. With Indigenous objects, there is an uncomfortable potential for different and possibly conflicting interpretations. This problem was discussed during a 2013 roundtable session titled “Archeology in the Service of Indigenous Peoples” hosted by the Association of Archeologists of Québec (AAC). The group’s conclusion was that it is necessary to “live with—and possibly even embrace—multiple interpretations” (Holliday 2013).

Though one can understand why Aboriginal objects have sometimes been given such ambiguous titles and descriptions in the past, the time has come to reconsider. Conservators have a responsibility to research, analyze, document, and release their findings on Aboriginal objects.

4.2. LOSS OF COLLECTIVE MEMORY

The definition of dissociation, according to the Canadian Conservation Institute is as follows: “*Dissociation results from the natural tendency for ordered systems to fall apart over time. Maintenance processes and other barriers to change are required to prevent this disintegration. Dissociation results in loss of objects, or object-related data, or the ability to retrieve or associate objects and data... It may result in loss of object value*” (Waller and Cato 2016).

The ordered system in question here is collective memory, both in museums and Aboriginal communities. The longer Aboriginal objects stay in obscurity, the fewer elders there will be who may have some living memory of them.

On the museum side, collective memory is proving to be a poor recording device. This is the second issue with the figurines: the curator responsible for these objects retired shortly after they were submitted for treatment. In the wake of budget cuts, the curator's position has been left unfilled. There are only a tiny handful of positions for curators and material culture experts who have knowledge of First Nations material in the province of Québec. Due to a perfect storm of government cuts coinciding with Baby Boomer retirements, these experts, with their knowledge and unpublished research, are being lost. In real terms, this results in aboriginal objects sitting on shelves—not lost, but un-findable.

The problem is further compounded when one examines the problem within Aboriginal museums. At the “Archeology in the Service of Culture” roundtable hosted by the AAC in 2013, Michelle Bélanger, director of the Abenaki Museum commented, “Our museum has 8,000 artifacts but no one in the community is qualified or able to document them” (Holliday 2013). That is dissociation.

In May 2013, the Québec Ministry of Culture and Communications released a report on the findings of a working group on the ensemble of the Québec museum network called “Le Rapport du groupe de travail sur l'avenir du réseau muséal Québécois” (Corbo et al. 2013). Section 4.2.4 of the report, which is based on briefs submitted by Aboriginal museums, concluded that there is a great need to include the expertise of First Peoples in the interpretation of their heritage. Additionally, on-reserve museums face an additional challenge insofar as they must also take into account their intangible heritage, participating in the transmission of the language and the culture as a whole.

Recommendation 28 of the report proposed an eight-point plan of action for Aboriginal museums and their social, cultural, and financial partners. The second point is of particular interest for conservators because it addresses a critically important step in the mitigation of dissociation risks:

To identify in situ (on-reserve) Indigenous collections, as well as in collections in other museums and institutions located in Québec and abroad.

4.3. POSSIBLE SOLUTIONS

There is a need to attract more First Nations peoples into conservation and museology in general and to prioritize the preservation of First Nations collections. Support for actions such as Recommendation 28 of the Rapport du groupe de travail sur l'avenir du réseau muséal Québécois that are driven by First Nations museums is essential.

Decision makers must be educated about the risks of dissociation and made to understand that it is a conservation issue. Wherever possible, analytical research should be done, so that all the available information about a given object can be properly recorded. This should result in more precise interpretations, leading in turn to more helpful titles and search terminology, even as we accept that our interpretation of these objects is not necessarily the only one. Lastly, the implementation of online inventories of Aboriginal art and objects in museum collections is needed in order to make objects “findable” by source communities and also to help bridge temporal knowledge gaps in the study of these collections.

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INHERENT VICE IN THE WOVEN STRUCTURE OF NORTHWEST COAST SPRUCE ROOT HATS

SARA SERBAN

ABSTRACT—This article investigates a selection of Aboriginal Northwest Coast woven spruce root hats in the McCord Museum collection, detailing the fabrication and treatment history of these objects. Examination revealed that conservation treatments had been undertaken on the majority of the hats at some point in their history, with several having undergone multiple interventions. Questions arose as to whether some repairs were traditional Aboriginal repairs made in communities where the hats originated, or resulted from later, non-Aboriginal handling. The hats, in the shape of truncated cones, are woven in a continuous circular line that starts at the center top of the crown and winds down through the brim to the outer edge. This complex weave structure can cause deformation, splits, and breaks in the finished object. Several of the treatments failed soon after they had been completed due to tensions in the weave, and similar tension-related issues were noted in areas of weakness. This raised a question as to whether the very process used to fabricate the hats results in inherent vice, where structural tensions in the finished product may in turn lead to challenges in its preservation.

RESUMEN—Este artículo investiga una selección de sombreros indígenas de la costa noroeste en la colección del McCord Museum, hechos de raíces de picea, detallando la historia de fabricación y tratamiento de estos objetos. El examen reveló que tratamientos de conservación se habían realizado en la mayoría de los sombreros en algún momento de su historia, con varios que han sido sometidos a múltiples intervenciones. Se plantearon preguntas sobre si algunas reparaciones eran reparaciones indígenas tradicionales hechas en comunidades donde los sombreros se originaron, o resultaron de manejo posterior no aborígen. Los sombreros, en forma de un cono truncado, se tejen en una línea circular continua que comienza en la parte superior central de la copa y sigue abajo a través de la ala al borde exterior. Esta estructura de tejido compleja puede causar deformación, divisiones y roturas en el objeto terminado. Varios de los tratamientos fracasaron poco después de que se habían completado debido a las tensiones en el tejido, y problemas similares relacionados con la tensión se observaron en áreas de debilidad. Esto plantea la cuestión de si el propio proceso utilizado para fabricar los sombreros resulta en un vicio inherente, donde las tensiones estructurales en el producto terminado generan retos para su preservación.

1. INTRODUCTION

The McCord Museum is a museum of Canadian social history in Montréal. Highlighted in its permanent collection of historical objects is a rich and diverse group of First Nations artifacts. As a means of showcasing this collection, in 2013 the museum mounted a permanent exhibition entitled *Wearing Our Identity*, which examines clothing and implements originating from several North American First Nations. The exhibition invites a discussion of the historical use and functionality of these objects in traditional and contemporary life, and as an expression of personal, political, and spiritual identity in First Nations cultures.

The scheduled exhibition length of five years has necessitated the rotation of objects, among which are five painted and woven spruce root hats from Aboriginal Nations on the northwestern coast of Canada, specifically from the Haida and Kwakwaka'wakw communities. These hats are similar in construction technique and

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material, as well as in issues of deterioration. Upon evaluation of each hat in preparation for display, it became clear that regardless of date or provenance, the difficulties in their preservation were virtually identical, leading to the conclusion that these hats possess inherent challenges due to both their fabrication technique and the material used. An important part of the research for this article has been an ongoing conversation with Haida weaver Isabel Rorick, whose generosity and insights have been invaluable.

2. GATHERING AND PREPARATION OF MATERIAL

In a discussion on Haida basketry, Knudtson (1991, 126) states that, “the woven Haida hat—an elaborate broad-rimmed headpiece constructed entirely from spruce root—is perhaps the single most elegant manifestation of Haida fiber art and is truly a feat of fiber engineering” (fig. 1). An integral part of the process of creating such an object involves the harvesting and preparation of the spruce root.

Sitka spruce is found throughout the Pacific coast rainforest, with a range extending approximately 3200 km from Mendocino County in California to beyond Cook Inlet, Alaska. Because the tree can tolerate limited quantities of salt, it can be found along sandy beaches or on rocky headlands exposed to salt spray. While the range in which the spruce is found is quite large, it is often difficult to find the desired traits suitable for basketry: shallow, lateral surface roots with long, straight lines. When gathering roots for use in weaving, the presence of sandy areas near the shore with few stones often indicates that the roots there will be long and straight. Roots located close to the surface with little taper are the most desirable for use in weaving. The mossy ground cover is gently removed and roots of an appropriate diameter are chosen. Harvested roots commonly span from 3–20 ft. (0.91–6.1 m), and in some instances can be up to 50 ft. (15.2 m) long (Harris 1995).



Fig. 1. Kwakwaka'wakw spruce root hat.



Fig. 2. Prepared roots split for twining and coiled for future use.
Courtesy of Isabel Rorick.

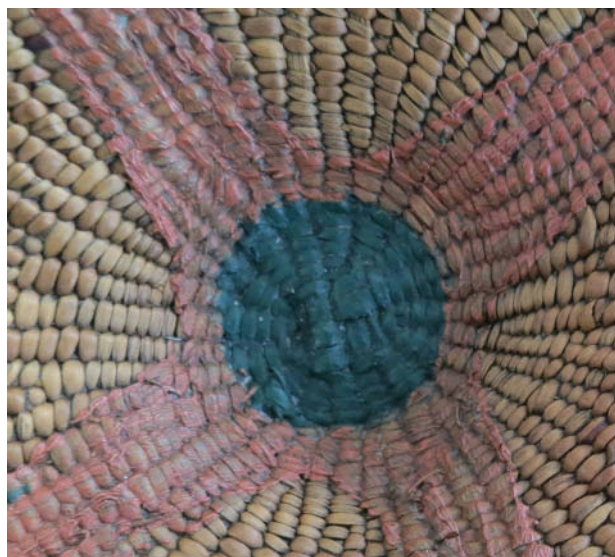


Fig. 3. Plain or two-strand twining on the top of a hat.

Within a day of lifting the roots from the soil and before they have had a chance to dry, the bark is removed. This is achieved by placing a coiled root on hot coals until the bark starts to peel; the root is turned and monitored until a hissing sound from the heated sap is detected, signaling that the root is ready to be stripped of its bark. The heated root is threaded through a split stick or board, the base of which has been inserted firmly into the ground. By pulling the root through the narrow opening, the bark is stripped away, exposing the cream-colored inner root (Busby 2003, 28).

The inner root is then split once, lengthwise. It can either be coiled and stored for use throughout the year, or the root may be further split and separated into warp and weft strands for twining (fig. 2). The root, once split, can be separated into three grades of material: the outer layer, which was originally covered with bark and has a glossy sheen; the second layer, which has a matte texture; and the pithy inner core (Emmons 1903). The outer layer is usually selected and split into finer strands for the weft of the hats, giving the completed hat a smooth, lustrous finish. The inner layer is used for the warp strands, while the pithy core is not used for weaving and is discarded.

3. WEAVING TECHNIQUES AND PROCESSES

The hats are woven using variations of twined weaving techniques. Detailed schematic diagrams of the various stitches used in spruce root twining can be found in Busby's 2003 book, *Spruce root basketry of the Haida and Tlingit*. Plain, or two-strand twining is the most common stitch and can be altered to produce a number of variations. The weft can be twisted around the warp in two directions, producing either an S or Z pattern; however, it is the Z-twist that is most commonly used in weaving Northwest Coast hats (fig. 3). Three-strand twining is frequently employed where more strength is necessary, and is often the technique used for the crown of the hat and the cylindrical hat ornaments known as *skils*. For this, three weft strands are used, each passing over two warps on the outside and under one warp on the inside, resulting in a long, fine, rope-like appearance on the outside of the hat, but resembling plain twining on the inside (figs. 4, 5).

Another variation of twining, known as twill twining, involves wrapping weft strands around pairs of warp strands, alternating the pairs with each successive row. Twill twining is used in combination with plain twining

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Fig. 4. Three-strand twining on the crown of a hat.



Fig. 5. Three-strand twining on the inside of the crown of the hat.

in order to create a series of patterns on the brim (fig. 6), resulting in a technique known as skip-stitch (Busby 2003). The geometric patterns commonly found on the brim—and in some instances the crown—have names such as spider web, salmonberry, slug trail, and dragonfly (Jonaitis 2006, 22). In her dissertation on spruce root hats, Glinsmann (2006) points out that these traditional pattern names oftentimes visually parallel their counterparts in the natural world, such as slug's trail echoing the zigzag pattern of a slug's meandering movement. To finish the hat, the ending—or edge of the brim—is completed with one of several distinctive styles of braiding. On the interior of the hat, a two-strand Z-twill twined headband is often incorporated.

Before the weaving process begins, the root strands are soaked in water to make them flexible. Once dry, the strands are quite hard and brittle. As it is impossible to soak the continuous warp strands once in place,



Fig. 6. Skip-stitch technique on the brim of a hat.

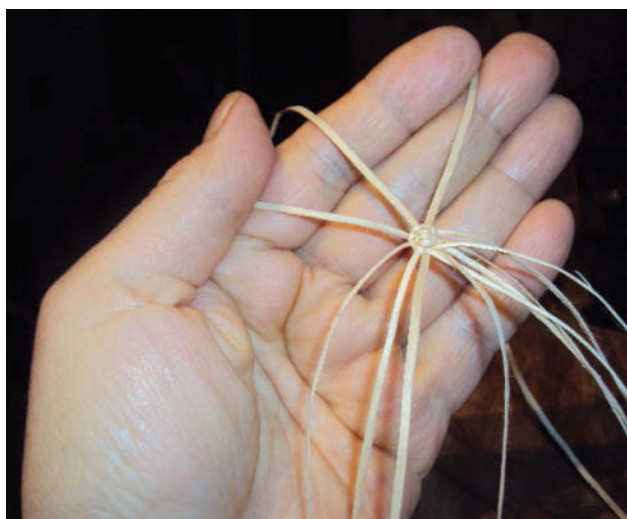


Fig. 7. Hat start. Courtesy of Isabel Rorick.



Fig. 8. Hat start with additional warp spliced in place. Courtesy of Isabel Rorick.

they are re-moistened as needed throughout the weaving process. In the case of Haida weaving, the hats are woven from the top down and are usually stabilized either over a wooden disc mounted on a wooden stand, or if outdoors, a stake that has been secured in the ground. A weight is positioned on top of the hat to keep it in place during the weaving process. Starting at the top, narrow strands of the inner spruce root are arranged in a series of crossed warp strands that radiate from a central point like the spokes of a wheel, around which one or more strands of weft are twined (fig. 7). This grouping of original warp strands remains continuous throughout the entire process of manufacture. Additional warps must be added as the diameter of the top increases, and they are spliced in where necessary (fig. 8).

At the point when the top has reached the desired diameter (and there are sufficient rows in place to assure the desired shape and tension), the warp strands are folded down (over the edge of the wooden disc) and the tension on the twined root is adjusted to bring about the desired shape for the crown. In Rorick's process of weaving, the transition between the top and sides of the crown is defined by a technique of twined braiding along the edge, after which three or four rows (or rounds) of three-strand Z-twining are woven (fig. 9). During



Fig. 9. Detail of top turn with twined braiding.

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its creation, the shape of a hat is modified by adding warp strands and adjusting the tension of the weft. For a finer, more compact weave, extra warp strands are spliced in. A finished hat, when properly woven, is water-tight. To facilitate this, weavers typically use an awl or similar tool to push the rows closer together during the weaving process. Throughout, warp and weft strands are trimmed and smoothed with a knife.

4. INHERENT VICE CONTRIBUTING TO TYPICAL DETERIORATION

The very process of harvesting and preparing the roots, with its associated cycles of wetting and drying over a period of several months, puts the plant fibers through a number of stresses. In addition to this, the practice of moistening the warp and weft strands of spruce root during weaving provides a more immediate and acute alternation between swelling and shrinkage. As Schaffer (1976, 131) explains, “The physical properties of bark and root deteriorate on long exposure to low relative humidities. . . Low and fluctuating relative humidity conditions are damaging, because they cause the weave of the artifact to become brittle, and the bark to lose its flexibility and pliability; the anisotropic dimensional changes may result in splitting of the object.” In addition to damage from changes in relative humidity, the roots are prone to deterioration from visible light exposure, which causes the root to darken, become embrittled and lose strength (Odegaard 1999). The five hats date from approximately 1850 to 1920, and the once cream-colored roots have become a lustrous brown due to oxidation.

The type of manipulation required to flatten the roots incorporates physical pressure that causes mechanical damage to the fibers, resulting in cell collapse (Florian et al. 1990). Warp strands that are bent and folded during weaving are damaged in the process—some fibers can be broken, and the warp strands themselves are compressed at the bend, causing further stress. If the warp strands are not moist enough when the first rows of the crown are folded down to start the sides, the strands can crack or break. Splits in the top disc may occur during shaping when the center is pushed in to form a concave shape, which pulls on the warp elements and can slightly separate the rows of twining. Trimming and smoothing the warp and weft strands with a knife during the weaving process may further weaken the material, as may the use of an awl to push the weft close together.

The top of a hat is a very tightly woven and contained structure; in contrast, the brim is capable of expansion and contraction with some buckling possible in the weave because the edge is open. Furthermore, the edge of the top is sharply defined and prone to abrasion.

The nature in which hats are used may also contribute to deterioration specific to this form of weaving. Hats are not handled in the same way as baskets, with resultant stresses occurring in different areas. Generally, baskets have the round disc on the bottom and open upwards, with straight sides. Hats are oriented in the reverse, and flare outward to the edge of the brim. When lifted from the top, the weave is pulled up slightly and a vertical stress occurs. If picked up by the brim, there are horizontal stresses in addition to the vertical ones. In comparison, a basket can be lifted from the bottom, with little dimensional change.

In general, the deterioration tends to occur in the same regions, with notably similar patterns. Extrapolating from this group of hats, the top disc, the top turn, and the crown regions seem to be the areas that are most fragile and susceptible to damage, which manifests itself through splits and associated losses. Many of the splits in the hats have a horizontal orientation. This involves partial or complete cracks through the warp strands, as well as breaks and losses in the weft strands twined around the warp (fig. 10). In some instances, there are losses in the warp, leaving holes in the weave.



Fig. 10. Cracks in warp strands and breaks and losses to weft strands.



Fig. 11. Old repairs with raffia-like material.

5. ASPECTS OF CONDITION AND TREATMENT OF THE HATS

All five hats required some degree of intervention before they could be placed on display, and three had previously undergone some form of treatment, in varying degrees of complexity.

A hat attributed to the weaver Isabella Edenshaw had undergone several treatment campaigns to reattach the top, which had become detached due to splits along the top edge, as well as to address horizontal breaks and losses in the woven structure of the crown. Available treatment documentation dates back to 1983 and reveals that the hat underwent numerous adhesive repairs. Three attempts were made to stabilize the breaks and re-adhere the top—first with methyl cellulose, then with wheat starch paste, and finally with wheat starch paste mixed with Lascaux 498HV and Lascaux 360HV. Adhesive repairs to the splits on the crown had been further stabilized with twisted strands of Japanese tissue placed diagonally between the weave and across the break, then adhered with wheat starch paste. Unfortunately, none of these treatments proved to be durable enough. Upon re-examination of the hat in 2006, the top was found to have completely detached from the hat and some of the breaks bridged with tissue had once again opened. As an adhesive repair did not seem to be flexible enough for this type of damage, the decision was made to sew the top back onto the crown with hair silk thread, which was further reinforced with small beads of wheat starch paste used to secure the ends of the stitching to the hat.

An issue often encountered was that of poorly executed previous repairs and their effects on the hat. One of the hats chosen for exhibition contained several old mends, which obscured the original shape of the hat and the painted design (fig. 11). The top of the hat had become detached and was split in numerous places; there were also horizontal splits with some associated losses on the crown of the hat. In addition, there were splits on the brim, though the damage was largely concentrated on the crown and along the top edge. Old repairs had been executed with a thick, fibrous, raffia-like material that had been partially sewn over and across the split and knotted on the inside of the hat, pulling the two sides together. In some places, the repair stitches were very tight, causing the woven matrix to pucker and bend. As a result, the silhouette of the hat was very misshapen—the top edge had become somewhat crimped, with a protruding lip where it would have previously been closer to a right angle at the point of transition. The thickness of the repair material caused further damage: it punched holes in weft strands, pushed the strands apart to create undesired spacing between the weft rows, and

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created additional cracks. In places where there were losses in one or more rows of woven root, the gap was hidden by tightly stitching the two sides together, creating a further distortion of the weave and making it difficult to assess the extent of the damage and losses until the old repairs were removed. Moreover, while detracting from the aesthetic focus of the hat, these repairs also compromised its structural integrity.

Upon initial examination, the question arose as to whether the repairs could be attributed to a member of the Kwakwaka'wakw community that made the hat. A visual survey was undertaken, evaluating an array of basketry objects in the McCord collection originating from various First Nation peoples. Because unrelated objects acquired from different donors and cultural communities were found to have similar repairs, it was determined that the repairs most likely originated in a museum setting. With this information, we felt that it would be an appropriate step to remove the stitched repairs to begin the treatment.

Once the old repairs had been removed, the hat was reset in its proper shape. By carefully stitching the splits closed, thread could be used to control the tension and apply gentle pressure across the break. Using hair silk thread, the two sides of a split were sewn together with short horizontal stitches on the outside of the hat, positioned parallel to the rows of root twining. On the inside of the hat, the stitches were positioned between two warp strands to bridge the split vertically (fig. 12). With this technique, the repairs were not visible, and the split was held together with light force on both the inside and the outside of the hat. The repairs were not made so tightly that the thread pulled or created new tension in the structure, or cut into the brittle fibers. At the same time, this method proved to be flexible enough that minor manipulation of the hat did not result in failure of the intervention, as had often been found with adhesive repairs.

Another problem often encountered with these hats is that of misaligned splits. A third hat presenting a comparable pattern of damage demonstrated two types of previous mends: splits on the brim that utilized the aforementioned raffia-like fiber sewing technique, and a subsequent adhesive-based intervention similar to that used on the Edenshaw hat. For the adhesive treatment, splits had been bridged with twisted strands of Japanese tissue and wheat starch paste, and along the top edge, flat strips of tissue had been adhered over the edge to the side of the crown. Although the majority of the repairs seemed to be stable, many of the splits were somewhat out of plane and portions of some strands of tissue had lifted (fig. 13).

Placing strips of twisted Japanese tissue between stitches to bridge splits and hold the two sides together is a technique commonly employed in repairing woven basketry (Odegard and Kronkright 1984; Barclay



Fig. 12. Diagram of stitching repair.

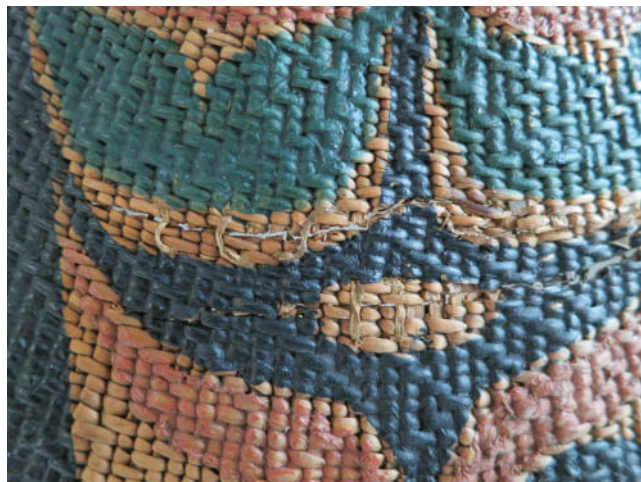


Fig. 13. Old twisted tissue repairs bridging the splits.



Fig. 14. Reshaping the humidified hat.

1989). While often a successful strategy, it was found that this type of repair did not always have enough strength to hold a split together when tensions in the weave structure pulled the two sides apart and out of plane. To address this challenge, the hats were first humidified to correct misshapen areas such as misaligned open breaks and detached tops that had flattened due to loss of tension. For this, they were placed in a humidification chamber outfitted with dishes containing cotton wool soaked in a mixture of deionized water and denatured alcohol. The alcohol was added to inhibit mold growth and to increase the penetration of moisture by reducing surface tension. Once the woven roots were sufficiently flexible, the hat was removed and reshaped using pieces of acid-free blotter and small carbon-fiber clamps (fig. 14).

With humidification, many of the hats regained their original form, making it easier to close the splits and stitch them together.

Fills for losses in woven sections were made with twisted strands of mulberry tissue that were toned with watercolors and adhered with wheat starch paste, the orientation of the fills imitating the Z-twist in the weave. Loss compensation along the twined braided top edge incorporated inserts made from paper pulp, as the twisted inserts made with tissue did not visually integrate with the surrounding material. Using silicone ear impression material, molds were taken of intact portions of the edge. Casts of the original form were then made with Sculptamold pulp casting material. The fills were tinted with watercolors and adhered in place with wheat starch paste (figs. 15a, 15b).

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Fig. 15. (a) The hat before treatment; (b) after treatment, splits in the hat stitched together and loss compensation using twisted Japanese tissue fills on the crown as well as a cast pulp repair along the top edge.

6. CONCLUSION

A survey of previous repairs and interventions in five spruce root hats from the McCord Museum Collection highlighted the tensions present in worn or weakened areas of their woven structures. Numerous previous attempts to stabilize splits with adhesive repairs had failed, while other Japanese tissue repairs had popped out or became partially detached. Distortions and loss of structural integrity in these areas of the objects contributed to their further deterioration. By studying both the properties of the construction material and the way that it was processed and handled during fabrication, further insight was gained into the hats' inherent weaknesses and to potential challenges for their preservation.

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SOURCES OF MATERIALS

Amaco Sculptamold

American Art Clay Co.
6060 Guion Rd.
Indianapolis, IN 46254-1222
Tel: (800) 374-1600
Fax: (317) 248-9300
www.amaco.com

Lascaux Acrylic Adhesive 498 HV and 360 HV*

Talas
330 Morgan Ave. Brooklyn, NY 11211
Tel: (212) 219-0770
www.talasonline.com

* Note: Lascaux Acrylic Adhesive 360 HV has been discontinued by the manufacturer.

Methyl Cellulose Adhesive Neutral pH Pure Wheat Starch

University Products Inc.
517 Main St.
Holyoke, MA 01040
Tel: (800) 628-1912
Fax: (800) 532-9281
www.universityproducts.com

Mulberry Japanese Tissue

The Japanese Paper Place
103 The East Mall Unit 1
Etobicoke, ON M8Z 5X9
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SARA SERBAN

Paraloid B-72 Ethyl methacrylate copolymer

TALAS

330 Morgan Ave.

Brooklyn, NY 11211

Tel: (212) 219-0770

www.talasonline.com

Siemens Steramould Silicone Ear Impression Material 660g (with hardener)

105A Great Russell St

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THE CREATION OF A DIGITALLY PRINTED REPRODUCTION SLEEVE FOR AN 18TH CENTURY PAINTED SILK DRESS

MIRIAM MURPHY, ALEXANDRA BARLOW, AND ERIC BREITUNG

ABSTRACT—This case study examines the use of digital printing for the conservation treatment of an 18th century Chinese painted silk *robe à la polonaise* in the collection of the Costume Institute of The Metropolitan Museum of Art, which had been accessioned missing its left sleeve. In anticipation of the spring 2015 Costume Institute exhibition *China: Through the Looking Glass*, the conservators decided to use digital printing to update the existing hand-painted replica sleeve. Although the original fabric was created with a combination of painted pigments and block printing, two earlier hand-painted reproduction sleeves proved that the 18th century textile was difficult to duplicate with the paints and fabric available in the 20th and 21st centuries. The fabric was recreated in collaboration with a digital printing studio. This article illustrates the challenges faced by both the conservators and the digital printing studio in the process of recreating painted historic fabric. Through a review of the treatment from start to finish, this case study presents resources and considerations for conservators using digital printing treatments in the future.

RESUMEN—Este estudio de caso examina el uso de la impresión digital para el tratamiento de conservación de un *robe à la polonaise* de seda pintada china del siglo XVIII en la colección del Instituto del Traje del Museo Metropolitano de Arte, que se adquirió faltando su manga izquierda. En preparación para la exhibición en la primavera de 2015 del Instituto del Traje, *China: Por el Espejo*, los conservadores decidieron utilizar la impresión digital para actualizar una manga réplica existente que se había pintado a mano. Aunque el tejido original se creó con una combinación de pigmentos pintados y xilografía, dos mangas de reproducción pintadas a mano recientemente demostraron que el textil del siglo XVIII era difícil de duplicar con las pinturas y tejidos disponibles en los siglos XX y XXI. La tela se recreó en colaboración con un estudio de impresión digital. Este artículo ilustra los desafíos enfrentados por los conservadores y el estudio de impresión digital en el proceso de recreación de la tela pintada histórica. A través de una revisión del tratamiento de principio a fin, este estudio de caso presenta recursos y consideraciones para tratamientos de impresión digital en el futuro.

1. INTRODUCTION

One of the objects selected for inclusion in the 2015 exhibition, *China: Through the Looking Glass*, at the Metropolitan Museum of Art's Costume Institute was a late 18th century *robe à la polonaise* that had entered the collection in 1976 missing its proper left sleeve. “*Robe à la polonaise*” describes a style of dress, popular in the late 18th century, that has a fitted bodice with an overskirt that was worn looped up with ties over a petticoat of matching or coordinating fabric (Van Cleave and Welborn 2013).

The selected *robe à la polonaise*'s dress and petticoat skirt were constructed in a Chinese block-printed and painted silk taffeta fabric. Since its accession, the dress had been exhibited four times: in 1982 in *The Eighteenth Century Woman*; in the winter of 1992–93 in *Fashion and History: A Dialogue*; in the winter of 1994–95 in *Orientalism: Visions of the East in Western Dress*; and in the 2004 exhibition, *Dangerous Liaisons: Fashion and Furniture in the Eighteenth Century*.

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2. CONSERVATION HISTORY

In order to include the dress in these exhibitions it had been necessary to create a reproduction sleeve. The Costume Institute's former curator-in-charge, Harold Koda, painted the first reproduction sleeve on polyester taffeta while he was a graduate intern in the late 1970s. That sleeve appears to have remained in place until preparations for the *Dangerous Liaisons* exhibition, when the conservator at the time, Chris Paulocik, observed that the sleeve had yellowed, so a new replacement sleeve was painted. For the same exhibition, digital printing was used to create reproduction woven jacquard fabric to make a new petticoat for a *robe à la française*. In 2006 Paulocik presented a paper on the creation of the petticoat fabric for the AIC Textile Specialty Group session (Paulocik 2006).

Intuitively, one would expect that a hand-painted replica of a hand-painted fabric would create the best reproduction, but after looking at the dress with its *Dangerous Liaisons* reproduction sleeve (fig. 1), it was felt that a better match could be created for this exhibition by using digital printing to replicate some of the hard-to-imitate characteristics of 200-year-old painted fabric. Digital printing has become a great tool for creating replacement fabric for textile conservators in recent years (Piechatschek and Britton 2008; Vuori and Britton 2008; Cole 2009; Bulgarella 2010; Takami and Roberts 2011). Murphy surveyed its usage in the field for her graduate studies thesis (2013) and presented a condensed version of her research at the AIC Textile Specialty Group session in 2012 (Murphy 2012).

3. TECHNIQUES AND CHARACTERISTICS OF 18TH CENTURY CHINESE BLOCK-PRINTED AND PAINTED SILK FABRIC

Over the last few decades, conservators and scholars have studied the techniques and history of 18th century Chinese painted silks and costume in depth (Paulocik and Flaherty 1995). The authors consulted the past research to gain a better understanding of the dress's fabric and the similar preservation issues that 18th century Chinese painted silks tend to share. In particular, research relating to material analysis, process description, and key identification markings of Chinese painted silks proved most helpful. The fabric of the *robe à la polonaise* measured selvage-to-selvage 29.5 in. (74.93 cm) with a continuous line of yellow at the selvage. These are two established characteristics that are found on Chinese silks and not on western painted silks of the 18th century (Skelton 1995).

The dress fabric's ground is off-white colored silk taffeta. The floral design was achieved through a layering of printing and painting. The floral outlines were first block printed, and these outlines were then over-painted, as can be seen in the brushstroke detail in figure 2. The colorful flowers and leaves of the design were then hand painted directly on the fabric. Past analysis (Skelton 1995) identified the use of white lead as an underlay in similarly painted silks. In the same study, malachite was found in green pigments on comparable 18th century painted silk fabrics. It was noted that the green pigments had more conservation issues than other colors on the design. The Costume Institute's *robe à la polonaise* also had cracking green paint on the leaves that had abraded the silk fibers, causing losses in the fabric.

4. TREATMENT ISSUES

Prior to the start of the reproduction project, particular characteristics of the fabric were identified as potentially difficult to reproduce. The block printing and hand painting created a layered appearance with variation in color and irregular placement of the floral motifs. In addition, the wear and deterioration of



Fig. 1. *Robe à la Polonoise* before treatment. France; ca. 1780; Silk; Purchase, Mr. and Mrs. Alan S. Davis Gift; The Metropolitan Museum of Art, 1976.146a, b. Photograph by Joyce Fung.



Fig. 2. Detail of the dress fabric showing printing and painting technique, and losses caused by the green pigment. Photograph by Miriam Murphy.

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the garment had caused the paint to chip and crack. The finer texture of the 18th century woven silk taffeta was also difficult to match when compared with available modern silk taffetas. Additionally, the ground fabric of the intact original proper right sleeve and bodice had substantial discoloration from wear around the underarms and it was important that the reproduction sleeve not stand out as a new addition.

5. CHOOSING THE DIGITAL PRINT SERVICE

Different resources for digital printing had been consulted after the decision was made to use this method for reproducing the fabric and ultimately Dyenamix, located in New York City, was chosen. The Costume Institute had recently worked with the studio on a custom dyeing project and was familiar with its past work. Dyenamix had previous experience working with museums and was enthusiastic about the project, offering in-person consulting. A meeting was set up with Dyenamix founder and head Raylene Marasco to visit the conservation laboratory to view the dress. She showed the authors samples of digitally printed fabrics that she had created for fashion designers and artists, and the goals for the project were explained.

5.1. PHOTOGRAPHY

The first step of the reproduction process was to create a digital image file of the textile. Fortuitously, the Cooper Hewitt, Smithsonian Design Museum has a fragment of what appeared to be the same Chinese painted silk textile in its collection. The Cooper Hewitt kindly created a high-resolution photograph of its flat fabric fragment to use for the digital print file so the dress did not have to be photographed (fig. 3). Ideally,



Fig. 3. Fragment; China; 18th century; tempera on silk; 32.5 × 56.7 cm (12 13/16 × 22 5/16 in.); Gift of Jacob H. Schiff; Cooper Hewitt, Smithsonian Design Museum, 1906-21-16-a. Photograph by Matt Flynn.



Fig. 4. The photograph of the petticoat (1976.146b) taken by Karin Willis for the digital file.

this image would have been used for the digital printing as it was a flat, unwrinkled piece of the fabric and not a three-dimensional object.

However, upon examination of the photograph of the fragment, it was discovered that while the block-printed design was the same as in the dress's fabric, the execution of the flowers was not the same. The pattern section from the dress is the mirror image of the Cooper Hewitt fragment's pattern. Different colors were used for details and darker tones were used throughout. Stylistic variations were apparent between the two painted fabrics. The fabric fragment from the Cooper Hewitt omitted some leaves and added buds and flowers, including an additional flower design not found on the fabric of the dress.

The differences were too noticeable to use the Cooper Hewitt's photograph, so an appointment was scheduled to have the dress's fabric photographed by Karin Willis in the Met's imaging studio. The petticoat of the dress was chosen for photography because it was the most easily transportable dress component and also presented a large clear area that would be easier to photograph. When photographing costume, it is difficult to capture a large flat area because of its three-dimensional construction (fig. 4).

5.2. CHOICE OF THE PRINT AREA TO REPRODUCE

Because of the amount of work required to clean up a large digital file for printing, it was decided to print only enough fabric to make the sleeve from the photograph of the petticoat fabric. However, it was unclear what part of the design should be printed, as there was no record of the appearance of the lost sleeve. The current painted replacement was bilaterally symmetrical to the other sleeve, but it should not be presumed

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that this was the nature of the original sleeve since the floral pattern is not symmetrically placed throughout the rest of the dress.

5.3. COMPARISON TO KNOWN COSTUME

Given the amount of fabric required to make a *robe à la polonoise* and its expense, one cannot assume that asymmetry was a conscious design decision. A portfolio of images of similar late 18th century dresses from the collection of the Costume Institute and other costume collections in the United States and Europe was created in order to determine the frequency of symmetry at the time. In consultation with the curators, the conservators decided to make the new reproduction in a way that was symmetrical to the original intact sleeve.

5.4. CHOICE AND PREPARATION OF FABRIC SUBSTRATE

Digital printing was chosen as the reproduction technique as it could recreate not only the layered pattern design but also the appearance of the ground fabric in a way that was visually similar to the 18th century silk taffeta.

Although digital printing can certainly help compensate for dissimilarities in ground fabrics, it is still beneficial to source the closest possible match available in weight to replicate the original fabric's drape. The silk taffeta #3303 from Calamo Silk in New York was the closest match found to the original fabric. The cost was also considered, and the Calamo silk was within budget. At the suggestion of Dyenamix, yardage was purchased in both white and ivory. Once purchased by the museum, the taffeta was sent to Jacquard Inkjet Fabric Systems in California for a proprietary chemical pretreatment for the digital printing process to help prevent bleeding of the inks as they are printed on to the fabric. After pretreatment the fabric was sent directly to Dyenamix.

5.5. MATERIALS SUPPLIED TO THE PRINTER

At the initial meeting with Dyenamix, it was decided that to assist the technicians, the conservators would send not only the digital image file created by the Met photographer, but the previous reproduction sleeve as well, since it is not itself an accessioned object. Typically, the firm is hired to create reproduction yardage from non-accessioned fabrics, so it is able to have the source material in its studio as a color reference while preparing the digital image file. The old reproduction sleeve was provided as a guide to the spacing and layout of the print but not for color matching, as it was decidedly not an accurate match.

5.6. THE MIMAKI TEXTILE PRINTER

Dyenamix has been using digital printing technology since 1999. According to Marasco, it was one of the first textile printing firms in the United States to use the Mimaki textile printers, which is the same manufacturer of the printers that it uses today. Based on the museum's previous experience with the company, it is clear that the familiarity that the technicians have with the machines greatly benefits their ability to make the correct adjustments to digital files to achieve the desired results.

The Mimaki textile printer can be used with both acid and reactive dyes depending on the fabric. The printers print 0.25 in. (0.63 cm) of the fabric at a time, passing over the same area eight times to fill it in. Different fabrics present different challenges when digitally printed. According to the Dyenamix team, wool fabrics have not been successful for digital printing as the fibers collect in the print head, needing to be

removed manually with tweezers after pausing the machine. It is interesting to note that according to the technicians working with these machines, it is the speed that has improved over time; the quality of the colors and image created is largely the same since the early use of these printers.

5.7. STRIKE-OFF REVIEWS

Slight adjustments to the digital file can sometimes be hardly seen on a computer screen, but can result in substantial differences in the printed fabric. Because of this, samples, known as strike-offs, must be printed and reviewed to find a perfect match.

The first strike-offs of the reproduction fabric were reviewed under 5 footcandle gallery lighting in the conservation laboratory. Approximately 10 versions of the fabric were brought in for review, and almost all of them were too dark in color due to the yellowed reproduction sleeve having been used as reference. It also became very clear in this first meeting that a particular challenge of the project would be metamerism, or the way that different colors are perceived under different light sources.

At the second review, eight new strike-offs were compared with the dress fabric (figs. 5, 6). Many of the issues from the first review had been solved. The ground fabric color had become more of a concern, as it proved difficult to match the uneven and worn look of the original under gallery lighting. To focus on this issue without the floral motif, strike-offs of only the ground fabric color were also reviewed (fig. 7).

For the third review, other conservators and the curators were consulted to help make the final selection.

5.8. THE PRINTED FABRIC

Overall, the project took about a month and a half to produce the final matching fabric. Because the reproduced area size was smaller than the printer's width, it was possible to print six identical repeats of the reproduced



Fig. 5. Comparison of strike-offs to the dress fabric during the second review. Photograph by Alexandra Barlow.

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Fig. 6. Comparison of digitally printed colors to the painted design of the dress fabric during the second review of strike offs. Photograph by Alexandra Barlow.



Fig. 7. Comparison of digitally printed ground colors to the dress fabric during the second review. Photograph by Alexandra Barlow.

area in order to have surplus (fig. 8). The ground color of the final fabric selected is slightly warmer to the eye than that of the original garment in standard lighting, but it matched better under gallery lighting.

6. SLEEVE CONSTRUCTION

After the fabric was received, a pattern was drafted with measurements from the right sleeve and adapted for the left sleeve. Historical pattern books (Waugh and Woodward 1968; Cunnington and Cunnington 1972;



Fig. 8. The final digitally printed reproduction fabric. Photograph by Miriam Murphy.



Fig. 9. Sleeve pattern cut from the digitally printed fabric with careful placement of the design in bilateral symmetry with the proper right sleeve. Photograph by Alexandra Barlow.



Fig. 10. The digitally printed reproduction sleeve sewn in to the dress, with the former hand-painted reproduction sleeve at right. Photograph by Miriam Murphy.

Arnold 1984) were consulted and multiple mock sleeves were created and adjusted before using the digitally printed fabric to create the final installation sleeve (fig. 9).

After the sleeve was constructed using similar hand stitching to the techniques found on the existing original sleeve, it was stitched to the armscye of the dress (fig. 10) and the *robe à la polonoise* was dressed on a mannequin and prepared for installation in the gallery (fig. 11).



Fig. 11 . Gallery View, Chinese Galleries, Douglas Dillon Galleries, Export Silk.
Photo: © The Metropolitan Museum of Art.

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7. ODDY TESTING OF THE FABRIC

While the Mimaki inks and the fabric pre- and post-treatment processes are described by the printers as “archival” and tested with 40 hours of dry cleaning resulting in no shift in color, Oddy tests were conducted to understand whether a corrosive environment is produced by the resulting printed fabric. The Oddy test is an accelerated corrosion test used as a museum standard for determining if a material is safe to use in close proximity to an object.

Metal coupons (copper, lead, and silver) are sealed along with the test material in airtight containers with elevated relative humidity and heated to 60°C for 28 days. The test as conducted for this project was evaluated on a scale of 1–5. A rating of 1 denotes no corrosion to the metal coupons and is suitable for permanent use; 2/3 is for slight corrosion visible under magnification and suitable for short-term use; and a rating of 4/5 is for visible corrosion and is not suitable for use near artwork. See Appendix for additional information.

7.1. ODDY TEST RESULTS

Due to insufficient time prior to the exhibition, printed fabric samples washed with Orvus as well as unwashed were Oddy tested after the exhibition. The overall result was that the digitally printed silk was approved for temporary but not permanent use, as it showed grades of 2/3 for the copper and lead coupons for the washed silk, and 2 for the copper and 2/3 for the lead for the unwashed silk.

8. GAS CHROMATOGRAPHY—MASS SPECTROMETRY (GC/MS) HEADSPACE EXPERIMENTS

The fabrics were further investigated by running solid-phase micro-extraction gas chromatography/mass spectrometry (SPME-GC/MS) headspace experiments. The GC/MS experiments are conducted to further determine the safety of the material for use with collections by identifying potentially harmful volatile components. The Oddy test temperature of 60°C was used to accelerate the vaporization of volatile components in the fabric for 45 minutes in a sealed jar. A stationary phase micro-extraction fiber or SPME fiber was used to collect the volatile compounds and allow for their transport into the GC/MS (see Appendix for additional information on the testing procedure). Both fabrics showed peaks for benzaldehyde (4.8 minute retention time (T_R)) and benzyl alcohol (6 minute T_R), where the area under the peaks was slightly less for the washed fabric. Other compounds were present in both fabrics including esters and aldehydes. More testing is required to know whether the concentration of a particular compound is great enough to cause corrosion in the Oddy test or similarly to cause degradation of the original fabric or dyes.

Based on the combined Oddy test and GC/MS data, the sleeve was removed from the dress for storage but retained separately for future display.

9. CHALLENGES

9.1. SUMMARY OF PRINTER'S CHALLENGES

Through a post-production interview, Dyenamix reported that the variation in color throughout the object was a challenge, as were the wrinkles that appeared in the digital image. They specified the difficulty of not having the object in their studio. Even a small sample would have expedited the work. They also recommended that if possible, a scanned image with shadows removed could be more useful than a photographed image.

9.2. SUMMARY OF CONSERVATORS' CHALLENGES

The conservators' challenges were primarily related to imaging and communication. It proved difficult to describe colors. Metamerism was a factor throughout the entire process, as well as the task of matching the subtle and uneven characteristics of 18th century fabric. In addition to these challenges, the strike-offs were mounted on flat paper, which impeded their comparison to the drape of the original fabric. The proprietary pre- and/or post-printing treatments of the fabric affected its hand so it could not be creased to match the wear deformation of the other sleeve's fabric. The fabric still had a slightly new appearance, especially around the underarm. Had there been more time, the areas might have been over-tinted with an acrylic paint wash to simulate discoloration from wear. Finally, the largest concern for the conservators was the testing results that did not approve this fabric for a long-term or more integrated treatment.

10. CONCLUSIONS

Overall, the digitally printed reproduction fabric sleeve was a success for the needs of the *China: Through the Looking Glass* exhibition. A digitally printed version of the 18th century fabric provided a more efficient and believable facsimile than one that could be hand-painted with modern materials today (figs. 12-13). Though effective for short-term display, the reproduction sleeve's long-term proximity to the original dress, based on the combined Oddy test and GC/MS data, was deemed inappropriate, and the sleeve was removed and retained separately for future display.



Fig. 12. *Robe à la polonaise* dress (1976.146a), before treatment. Photograph by Miriam Murphy.



Fig. 13. *Robe à la polonaise* dress (1976.146a), after treatment. Photograph by Miriam Murphy.

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APPENDIX: EXPERIMENTAL

1. Oddy test

A variant of the British Museum's Oddy test was used, where three tubes were prepared for each material and each tube housed a single metal coupon of lead, copper, or silver (Green and Thickett 1995; Robinet and Thickett 2003). Rather than hanging the metal coupons from a wire, a silicone rubber stopper was used as described by Robinet and Thickett in 2003. The Pyrex test tubes were 20 cm long and 2.5 cm diameter, and were sealed with #4 silicone stoppers (STI Components, Inc. #4120-004). One 0.75 mL Pyrex culture tube with 0.4mL of water was placed in each larger test tube. Two-gram samples were prepared for each tube, and each test was run in duplicate (six tubes per test). The samples were cut into approximately 0.5 × 2 in. pieces prior to placing them into the test tubes. Sealed tubes were placed in aluminum test tube racks vertically with an external plate strapped to the top in an attempt to keep the stoppers in place. It should be noted that in several cases, the stoppers slipped by up to 10 mm from their original position by the end of the test. This may have altered the results by allowing volatiles to escape the tubes.

2. Solid Phase Micro-Extraction Gas Chromatography/Mass Spectrometry

SPME-GC/MS was used to assess the volatile and semi-volatile compounds being emitted from the printed fabrics. Two grams of the fabric were prepared in 0.5 × 2 inch pieces and placed in a 125 mL wide mouthed septa-lidded jar (Thermo Scientific #S320-125). A Supelco DVB/CAR/PDMS fiber (Aldrich #57328-U) was inserted into the jar through the septum, and the jar and fiber were heated at 60°C for 45 minutes. The fiber was then removed and injected into a cryotrapped Agilent 6890N GC/ 5973N MS system with the following parameters: 250°C inlet, 2 minutes desorption, 45°C oven ramped to 175°C at 10°C/min, then to 250°C at 15°C/min and held for 3 min.

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THE CREATION OF A DIGITALLY PRINTED REPRODUCTION SLEEVE FOR AN 18TH CENTURY PAINTED SILK DRESS

SOURCES OF MATERIALS

Dyenamix Inc.

158 Lafayette St., 2nd Floor
New York, NY 10013
Tel: (212) 941-6642
Fax: (212) 941-7407
www.dyenamix.com

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PO Box 426
Healdsburg, CA 95448
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Fax: (707) 473-9083
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UNINTENDED CONSEQUENCES OF THE USE OF RARE-EARTH MAGNETS IN MOUNTING OBJECTS ON OPEN DISPLAY

JOHN D. CHILDS AND MAUREEN MERRIGAN

ABSTRACT—The National September 11 Memorial & Museum used rare-earth magnets in a mounting system for its first commissioned work of art, an installation of 2,983 watercolors titled *Trying to Remember the Color of the Sky on That September Morning*, by artist Spencer Finch (2014). The watercolors were on open display, attached to a steel armature in a variegated pattern using magnets. The installation method presented problems immediately. Ferromagnetic dust was attracted to the surface of watercolors above each magnet, causing disfiguring accumulations. Cleaning using low-tack pressure-sensitive adhesive tape failed to correct the problem, and an alternative mounting system was required. Self-adhesive hook-and-loop fasteners were affixed to the back of each watercolor. This mounting system also failed, as dimensional changes in the paper caused the fasteners to peel away. Finally, a successful system that improved dimensional stability and relied on mechanical fasteners rather than pressure-sensitive adhesive was developed. Hook-and-loop fasteners were stapled to mat boards, and the mat boards were attached to the watercolors with Jade-R adhesive. The project demonstrated a potential problem in the use of magnets for mounting artwork on open display. It also demonstrated the need for flexibility, creative thinking, and cooperation in dealing with the unexpected in a museum setting.

RESUMEN—El Memorial & Museo Nacional del 11 de Septiembre usó imanes de tierras raras en un sistema de montaje para su primera obra de arte encargada, una instalación de 2983 acuarelas titulada *Trying to Remember the Color of the Sky on That September Morning*, del artista Spencer Finch (2014). Las acuarelas se exponían sin vitrinas, atadas a una armadura de acero usando los imanes. El método de instalación presentó problemas de inmediato. Cada imán atrajo el polvo ferromagnético ambiental a la superficie de las acuarelas, causando acumulaciones oscuras. La limpieza con cinta adhesiva de baja adherencia no logró corregir el problema, y se requirió un sistema de montaje alternativo. En la parte trasera de cada acuarela se fijaron cierres de gancho y bucle autoadhesivos. Este sistema de montaje también falló, ya que los cambios dimensionales en el papel causaron que los cierres se soltaran. Finalmente, se desarrolló un sistema exitoso basado en sujetadores mecánicos en lugar de adhesivo, que mejoró la estabilidad dimensional. Los cierres de gancho y bucle se graparon a cartulina de enmarcar, y las cartulinas se unieron a las acuarelas con el adhesivo Jade-R. El proyecto demostró un problema potencial en el uso de imanes para montar obras de arte sin vitrinas. También demostró la importancia de la flexibilidad, el pensamiento creativo y la cooperación cuando abordando lo inesperado en los museos.

1. INTRODUCTION

Opening a new museum presents interesting challenges that require nimble responses and quick thinking. Installation techniques that have worked successfully elsewhere can fail in unexpected ways, and procedures for handling exhibition problems may not be fully developed. Conservation staff must be prepared to respond, sometimes on the fly and sometimes with perseverance. In May 2014, the newly opened National September 11 Memorial & Museum (9/11 Museum) was presented with a challenge that needed both an immediate response and a long-term solution, requiring both agility and stamina.

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Prior to opening, the 9/11 Museum commissioned an artwork from artist Spencer Finch titled, *Trying to Remember the Color of the Sky on That September Morning*. Consisting of 2,983 watercolors on paper, each painted a shade of blue, the work occupies an enormous wall situated between two galleries in a space with heating and air conditioning, but without added humidification or dehumidification. The original mounting system for the watercolors used rare-earth magnets affixed to the backs of the watercolors. Rare-earth magnets were selected because of their demonstrated usefulness in creating non-intrusive, easily concealable mounts for flat objects such as paper and textiles, and were already being successfully used in many mounts throughout the 9/11 Museum.

Time constraints surrounding the scheduled opening of the museum required the installation of the artwork to take place while work was still being carried out on the building fabric. Even before the museum opened, the magnets began to attract atmospheric dust to the surfaces of the watercolors, requiring a rapidly organized program of in situ cleaning. Eventually, the maintenance required for continuing with a magnet-based mounting system was deemed unsustainable. Other mounting options were explored in consultation with the artist and professional colleagues, and a system using hook-and-loop fasteners backed with acrylic pressure-sensitive adhesive was selected. This second mounting system was installed in November 2014 and began to fail almost immediately.

With the failure of the second mounting system, a more comprehensive program for exploring mounting options was developed. Various mechanical methods of securing each watercolor were investigated, and after careful testing, it was decided to adhere the watercolors overall to squares of four ply mat board using Jade-R adhesive. The mat board squares were cut slightly smaller than the watercolors and hook-and-loop fasteners were attached mechanically to the back of each board with stainless steel staples. Installation of this third mounting system required the use of 125 substitute watercolors supplied by the artist to use as placeholders while the originals were rotated out for remounting. The process took approximately three months and was completed in September of 2015.

2. RARE-EARTH MAGNET MOUNTS

2.1. INITIAL INSTALLATION

Many New Yorkers remember that the morning of September 1, 2001 was incredibly clear with a beautiful blue sky overhead. The crystalline sky quickly became the backdrop for a coordinated terrorist attack that remains one of the greatest tragedies in American history and forever changed the world. In the aftermath of 9/11 there was a spontaneous and immediate need to memorialize the lives lost. Within the museum's collection is an extensive assemblage of artistic expression created in tribute to the victims of the September 11 attacks. One commissioned work in particular has a significant impact on visitors' experience of the museum. The design of the museum called for a work to unite the two major exhibition galleries, leading visitors from a space of memorial to a space of history and back again.

A proposal from artist Spencer Finch, a New York-based artist perhaps best known for working with the themes of memory and perception through light installations, was selected to complete this challenging design directive. He proposed an installation of 2,983 watercolors, each painted a different shade of blue—2,983 to honor the 2,977 victims of the 9/11 attack plus the six victims of the earlier 1993 World Trade Center bombing, and the shades of blue to represent the clear blue sky of that morning. The title of the piece, *Trying to Remember the Color of the Sky That September Morning*, acknowledges the artist's and our own inability to precisely remember the chaos of that day—and perhaps the world—before September 11.

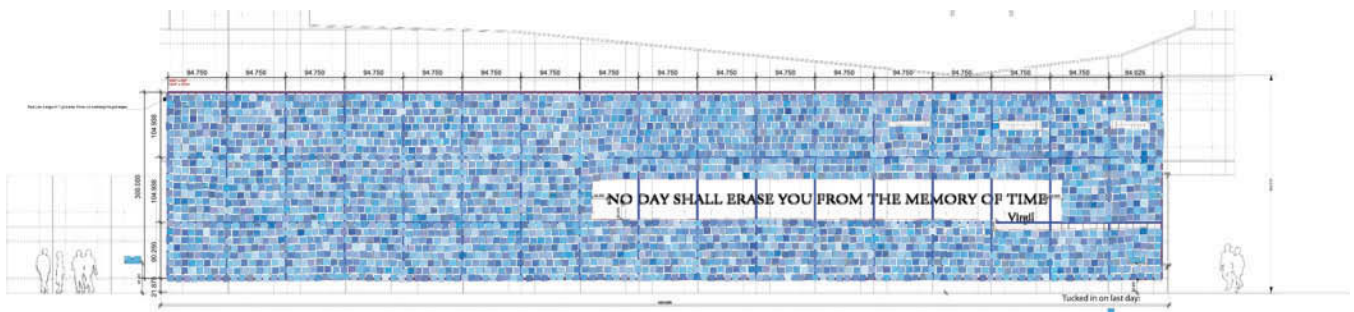


Fig. 1. Design for installation of *Trying to Remember the Color of the Sky on That September Morning*, Spencer Finch (American, b. 1962), watercolor on paper, courtesy 9/11 Memorial Museum.

The proposed installation filled an entire wall of the museum's interstitial spaces between the North and South Tower galleries, approximately 170 ft. $\times$ 70 ft. (52 m $\times$ 21 m). After consideration of several different designs and an initial test using a steel mesh grid mounting system and metal bulldog clips, a final design was selected (fig. 1).

The final design specified a rectangular installation leaving a void to accommodate a quote from Virgil's *Aeneid*, "No Day Shall Erase You From The Memory of Time," forged from steel recovered from the World Trade Center by artist and blacksmith Tom Joyce. Additional voids were left in the top right section to accommodate the HVAC vents. The watercolors, each 11 inches square, are painted on 100 lb. heavy-stock paper and are individually mounted to the wall. The design intent is to have each watercolor mounted in such a way that only the paper, and no mounting attachments, is visible to the viewer. The watercolors appear to "float" on the wall (fig. 2).

Working with the artist, a second mock-up was created to test various mounting systems. The artist wanted the piece to feel organic and was concerned with being potentially constrained by the grid. Additionally, he wanted to be able to easily move pieces around during the installation to achieve a varied distribution of



Fig. 2. Installation of *Trying to Remember the Color of the Sky on That September Morning*, Spencer Finch (American, b. 1962), watercolor on paper, courtesy 9/11 Memorial Museum, photograph by Jin S. Lee.

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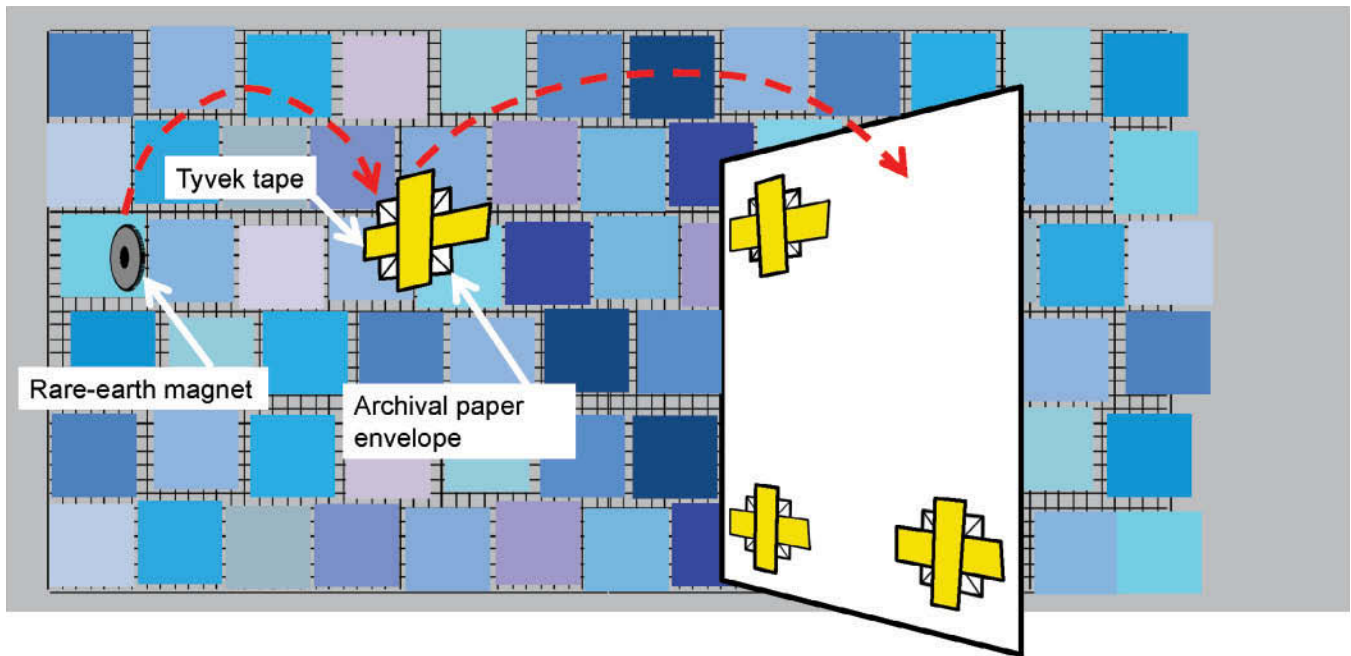


Fig. 3. Original mounting method using rare-earth magnets, courtesy 9/11 Memorial Museum, illustration by John D. Childs.

the different shades of blue. To this end, a mounting system using a steel mesh grid attached to the wall and rare-earth magnets attached to the watercolors was devised (fig. 3).

One-inch diameter rare-earth magnet rings were placed in coin envelopes made of archival paper and then taped to the back of each watercolor using Tyvek tape, which employs a pressure-sensitive acrylic adhesive. The watercolors were then installed and moved around the steel grid to achieve the artist's desired layout. The highest point of the installation is approximately 22.5 ft. (6.82 m), so scissor lifts were used to access the highest points.

2.2. MAGNET MOUNT FAILURE

Installation was postponed as long as possible during the museum's construction, but due to construction delays and a firm opening date of May 15, 2014, *Trying to Remember the Color of the Sky That September Morning* was installed while some construction was still ongoing. Polyethylene sheeting was draped in front of the work as sections were installed to help protect it from damage, but it quickly became apparent that there was a problem with the magnets. Approximately 10 days before the museum's dedication it became evident that the magnets were attracting dust from the atmosphere. The dust was accumulating on the front of the watercolors in circles corresponding with the location of the magnets on the back (fig. 4). With no time to consider a new mounting system before opening day, the watercolors were cleaned in situ by applying low-tack pressure-sensitive tape (FrogTape delicate-surface painting tape) to the affected areas and removing it by peeling at an acute angle. This technique was tested on sample watercolors and approved by Spencer Finch before being used on the artwork itself. The entire installation was cleaned before the dedication and the museum opened on time.

Once the museum was open to the public, the artwork became almost instantly iconic. It is one of the most photographed works in the collection and it resonates beautifully with visitors. But the initial problem with the magnets remained. It had been assumed that the ferric dust in the air that was attracted to the magnets was a result of the ongoing construction and cleanup prior to the opening. Now that the artwork was

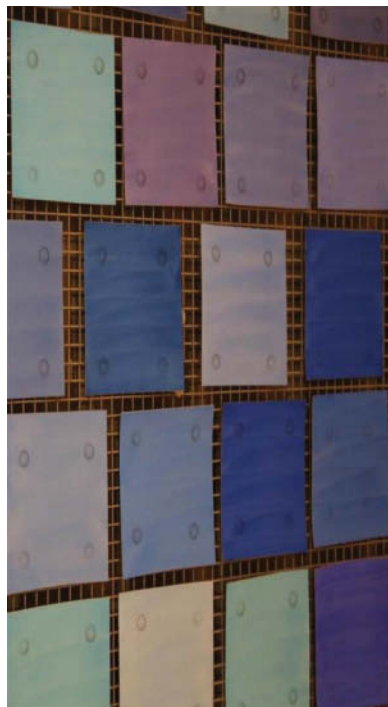


Fig. 4. Dust accumulation on watercolors caused by rare-earth magnets, courtesy 9/11 Memorial Museum, photograph by Maureen Merrigan.

in a “clean” environment in which construction had ceased and outside air was being filtered by the building’s HVAC system, it was believed that the problem would not recur. But, within three months of the museum’s opening and the initial cleaning, the dark rings began to reappear on the watercolors. Again attributed to remnant construction dust, a second tape cleaning was undertaken with the hope that it would be the last time such a treatment would be necessary. Unfortunately, this was not the case.

In July 2014, the bottom 10 rows were cleaned, as they could be easily accessed with ladders and were the most visible to visitors. Resources were tight during this time period with every department in the museum adjusting to running a newly opened site, with all the unplanned surprises that come from receiving an average of 8,000 visitors per day.

Disappointingly, the magnetic dust accumulation did not cease. Just one month later, in August 2014, it was apparent that another cleaning was needed, and that an alternative to the magnetic mounts was necessary. Continuous cleaning of the piece was not an option for many reasons. Primarily, the delicate surface of the watercolors was not capable of surviving repeated tape application and removal. Additionally, all work had to occur when the museum was closed. The exhibition space where the work is installed cannot be blocked from view since it is a main thoroughfare in the museum, and bringing in heavy equipment during operating hours poses a risk to visitors. The museum is open approximately 11 hours a day, seven days a week, 365 days a year, making off-hours work challenging for staff and difficult to schedule.

2.3. DUST ANALYSIS

To confirm that magnetic particles were accumulating on the surface of the watercolors, the museum contracted environmental testing company TRC Environmental to analyze dust removed from the watercolors and to sample the air in the museum. The air sampling, which was performed over one night, did not detect iron particles,

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Fig. 5. Similar dust accumulation on sign at Hudson Eats Restaurant adjacent to 9/11 Memorial site, courtesy 9/11 Memorial Museum, photograph by Maureen Merrigan.

indicating a concentration of airborne iron particles below the 100 parts per million detection limit. The building uses MERV 8 pre-filters, which are rated to remove particles of 3–10 μm with a 70% efficiency, and AstroCel 1 HEPA filters, which are rated to remove particles of 0.3 μm or greater at 99.97% efficiency. The dust sample was analyzed using polarized light microscopy, stereomicroscopy, scanning electron microscopy, and energy dispersive x-ray spectrometry. Particle classification of the sample revealed that 70% of the particles removed were iron oxides, with quartz, calcite, paper, skin fragments, and paper pulp making up the majority of the remainder. Confirmation of the presence of iron-containing particles prompted an investigation into possible sources.

Research suggests that car traffic contributes greatly to airborne iron particles, both from brake dust and combustion engine emissions. An additional source could be from incinerators, which are common in older buildings in New York. The main products of incineration are hematite and magnetite. Adjacent to the museum there is a complex of buildings that has at least six incinerators. All of these sources must create some percentage of iron particles smaller than 1 μm . The #1 train line, the R train line, and a branch of the New Jersey PATH train also border the museum and potentially contribute to brake dust levels.

Empirical observation was used to support this research and testing, specifically that iron dust was coming from the external environment surrounding the museum. Indeed, a metal sign using magnet mounts at a restaurant approximately 8000 ft. (2440 m) from the museum was found to be accumulating dust in the exact same manner as the watercolors in the museum (fig 5).

3. HOOK-AND-LOOP MOUNTS

3.1. INITIAL EXPLORATION

In August 2014, a third cleaning of the bottom 10 rows was undertaken, and the process of developing a new mounting system was begun. A team including museum curators, conservators, exhibitions staff, and the artist considered several options. One possible solution considered was to continue to use magnets but to

increase spacing between the watercolors' surfaces and the magnets on the reverse with the aim of eliminating the dust problem. To test this possibility the magnets were removed from their envelopes and hook-and-loop strips were adhered to the magnets with their self-adhesive backings. The other sides of the hook-and-loop strips were then adhered to the envelopes still attached to the watercolors' reverse sides. Joining the two sets of fasteners together provided approximately 0.25 in. (6.4 mm) of additional distance between the magnets and the watercolors' front surfaces. Although this slowed the accumulation of dust, after four weeks of testing it was apparent that creating a greater distance did not resolve the dust accumulation.

3.2. SELECTION AND IMPLEMENTATION OF SECOND MOUNTING SYSTEM

Armed with information about iron-containing dust in urban environments, participants in the project agreed that elimination of magnets from the mounting system was essential to prevent continued dust accumulation. Criteria for the new mounting system included the potential for non-uniform arrangement of individual works on the wall. The placement could not be restricted to the steel mesh's grid lines. It also had to be visually unobtrusive, and be completed without any major interruptions to visitors' experience of the artwork during museum operating hours.

Building upon the hook-and-loop experience described above in Section 3.1, the team developed the following mounting technique and a mock-up was installed for two weeks. This test was deemed successful and the method was chosen for implementation. The magnets were removed from their envelopes, and strips of the hook side of the fasteners were attached to the back of the envelopes. Leaving the envelopes in place allowed for a quicker remount process by eliminating the need to remove the Tyvek tape used to secure the envelopes to the watercolors. On the steel mesh grid, two long strips of the loop side were positioned using the pressure-sensitive adhesive backing and secured in place by passing two zip ties through the top corners to the grid (fig. 6). The magnets were judiciously removed by opening the envelopes with scalpels. Each watercolor had four magnets, so this process was repeated 11,932 times. Magnet removal began in

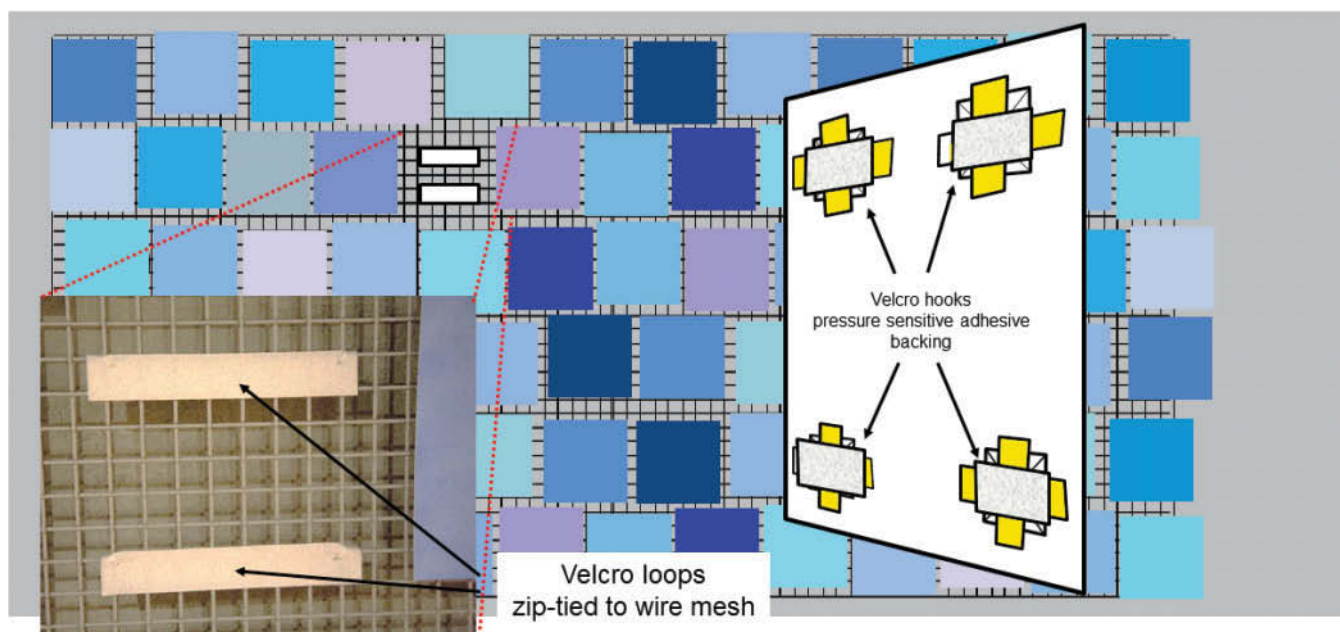


Fig. 6. Second mounting method using hook-and-loop fasteners attached to watercolors with pressure-sensitive adhesive, courtesy 9/11 Memorial Museum, illustration by John D. Childs.

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Fig. 7. Failure of pressure-sensitive adhesive on hook-and-loop fasteners, courtesy 9/11 Memorial Museum, photograph by Maureen Merrigan.

November 2014 and a crew of four worked for eight hours each weeknight while the museum was closed. The entire re-mounting was completed in four weeks.

3.3. SECOND MOUNT FAILURE

Shortly after the reinstallation was completed, problems arose with the adhesive attaching the hook-and-loop fasteners to the backs of the watercolors. The adhesive would fail on at least one corner of a watercolor, leaving it to dangle at an odd angle (fig. 7.) This form of failure would manifest on one or more watercolors several times a week, making regular repairs and reinforcements necessary. Additionally, some watercolors began to undulate as a result of fluctuations in relative humidity—there was a differential between the ambient RH in the space and the RH behind the watercolors due to the close proximity to the relatively recently poured concrete wall. The repeated curling and relaxing eventually caused the adhesive on the hook-and-loop fasteners to fail and detach from the back of individual watercolors. Every morning, collections staff would arrive two hours before the museum opened to make sure each watercolor was well secured. Thankfully there were very few incidences of the watercolors completely detaching from the wall, but it quickly became evident that this mounting method was also not sustainable. Pressure-sensitive adhesive could not be relied on to secure the watercolors in the existing environment.

4. HYBRID MOUNT SYSTEM

4.1. SYSTEM DEVELOPMENT

Another round of testing and research was begun to identify an effective mounting method. As the loop strips attached to the steel mesh grid remained firmly in place with no detachment issues, it was decided to leave them in position and devise a new system that could utilize them. The new system was developed once again in close consultation with Spencer Finch to ensure that it continued to achieve his desired visual effect. It was decided that attaching each watercolor to a mat board would provide dimensional stability, restrict the

RH-related planar fluctuations that had caused the failure of the previously described mounting system and would not cause any visual interference. First, hook strips would be stapled to the mat board, providing a mechanical (i.e., non-adhesive) connection. The watercolor would then be attached to the mat board with an adhesive. Finch generously created additional watercolors for experimentation purposes. First, a variety of hinging methods were tested including gummed cambric tape, Tyvek tape, and Japanese paper. Four sets of Japanese paper hinges were tested using the following adhesives: wheat starch paste; Jade-R, a modified ethylene vinyl acetate copolymer that remains water-soluble; and the acrylic dispersion adhesives Lascaux 360 HV and Lascaux 498 HV. Additionally, full adhesion of mat board to watercolor was tested using three rolled-on adhesives: Lascaux 498 HV; Jade-R; and Rhoplex AC-2235M, another acrylic dispersion adhesive. Simple peel tests indicated that some of these methods did not provide sufficient bonding to resist the movement of the watercolor paper. The four most effective mounting methods were selected for further testing in situ to see how they would perform in the actual installation environment.

4.2. SYSTEM TESTING IN SITU

A selection of samples using various mounting methods were prepared for installation in-situ, including: 10 samples with four 1.5 in. (3.8 cm) cambric tape and water-soluble gum adhesive hinges; 10 samples with four 1.5 in. (3.8 cm) Japanese paper and Lascaux 498 HV hinges; five samples with full adhesion of mat board to watercolor with Lascaux 498 HV; and five samples of full adhesion of mat board with Jade R. These test samples were placed between two HVAC vents, which had previously been an area with the highest rate of failure of the pressure-sensitive adhesive (fig. 8).

All of the sample mounting techniques resulted in watercolors that stayed flatter than those attached only with hook-and-loop fasteners, achieving the desired result of an overall artwork that had less three-dimensional “movement.” After being installed for three weeks, the 30 watercolors were inspected and evaluated. During the test period, none of the samples became dislodged or fell. Closer inspection, however, revealed that both hinging methods had begun to fail, particularly the cambric tape hinges, many of which detached completely. The Japanese-paper/Lascaux 498 HV adhesive hinges exhibited partial failures, with the hinges beginning to separate from the paper. Of the full adhesion methods, the Lascaux 498 HV samples had

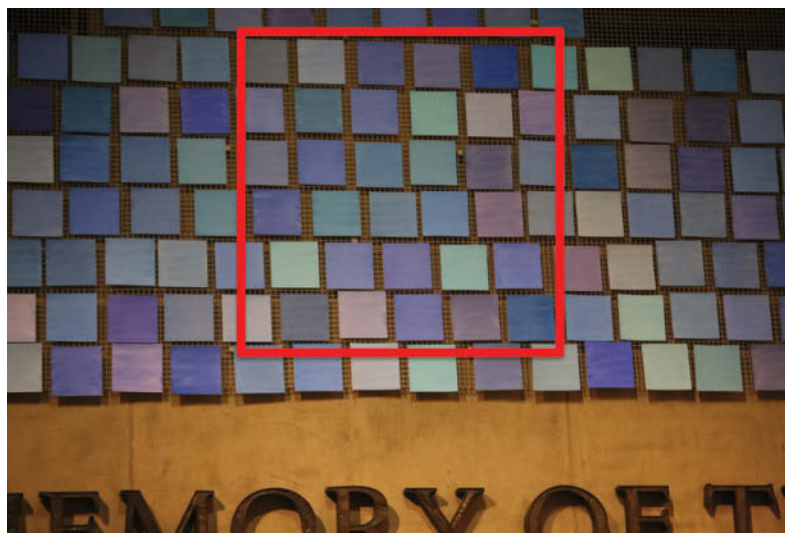


Fig. 8. Arrangement of test mounted watercolors, courtesy 9/11 Memorial Museum, photograph by Maureen Merrigan.

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begun to separate at one or more corners, while the Jade-R samples remained completely attached. While any of these techniques would have made some improvement over the pressure-sensitive adhesive hook-and-loop mounting system, the team concluded that Jade-R fastened the mat board to the watercolors most securely. It had the additional advantage of being significantly less expensive than the Lascaux, and was easier to apply than hinging 2,983 individual works. Thus, the overall application of Jade-R to secure mat boards to the back of each watercolor was selected as the third mounting system for the entire work.

4.3. INSTALLATION OF THIRD MOUNTING SYSTEM

The third mounting system was designed to use 9 in. $\times$ 9 in. (22.9 cm $\times$ 22.9 cm) mat boards (slightly smaller than the watercolors), Jade-R adhesive, hook-and-loop fasteners, and rustproof Monel alloy staples (fig. 9). Each watercolor would need at least 48 hours of drying time for the adhesive, but large portions of the installation could not be missing while this work occurred. To solve this problem, Spencer Finch created a set of placeholder watercolors that were installed when the originals were taken down for remounting. This allowed 100 to 150 paintings to be de-installed for remounting at a time, and allowed all work to be performed during regular business hours. In May 2015 the remounting process was begun at the very top of the installation and proceeded left to right along the rows. In the morning before the museum opened, 100 to 150 watercolors were de-installed and placed in numbered file folders. Placeholder watercolors were installed in their stead and the original watercolors were brought to the laboratory, where the Tyvek tape and envelopes were first removed from the backs of the watercolors. Then Jade-R was applied to mat boards (already with hook strips stapled in place) using a roller, and the mat boards were placed on the backs of the watercolors. Watercolors with completed mounts were stacked in groups of 10 with blotter paper interleaving and fastener strips aligned to prevent distortions, and weighted at the top while drying. The original timeline called for completion of the project by October 2015. The remount timeline needed to be shortened, however, to accommodate the arrival of a very special visitor, and work was completed on September 16, 2015.

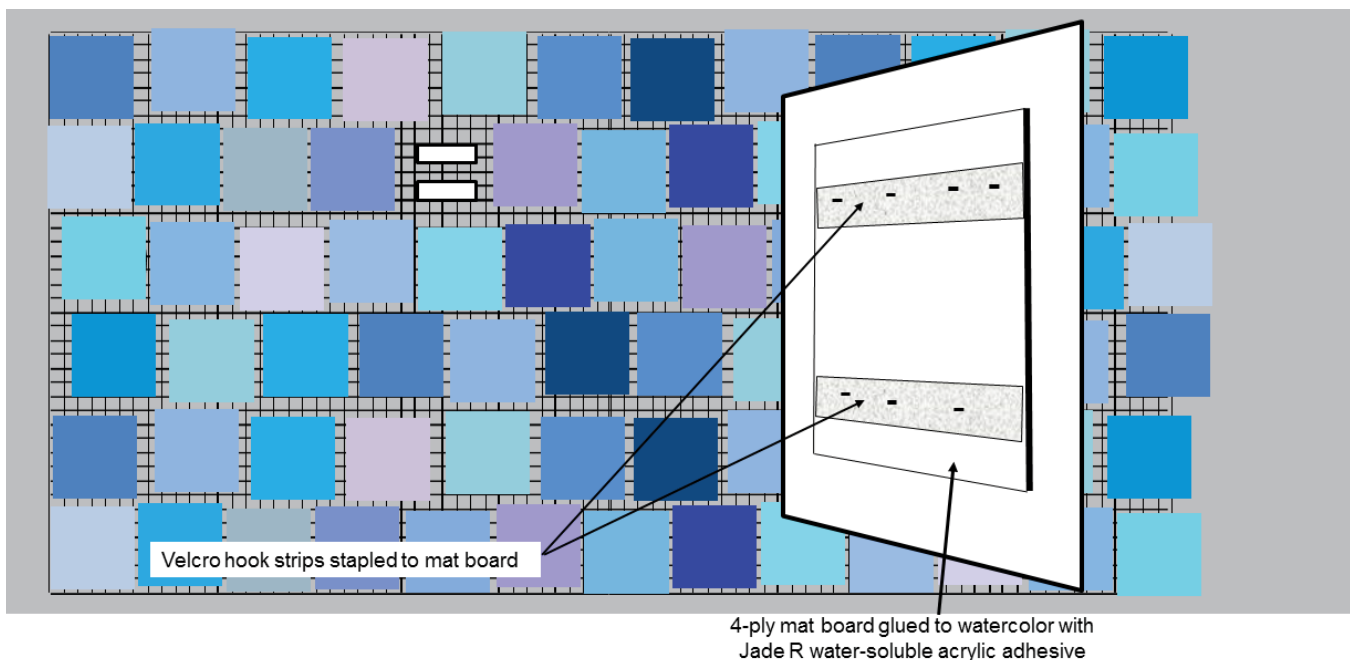


Fig. 9. Third mounting method using mat boards adhered to watercolors with Jade-R, and hook-and-loop fasteners stapled to mat boards, courtesy 9/11 Memorial Museum, illustration by John D. Childs.

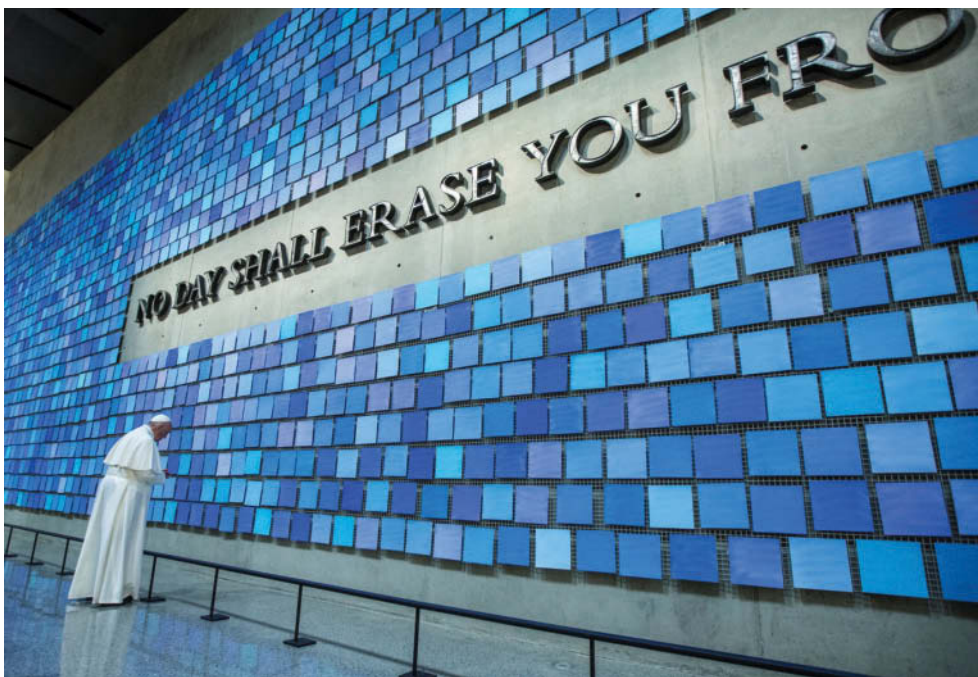


Fig. 10. Pope Francis visits 9/11 Memorial Museum, September 25, 2015, *Trying to Remember the Color of the Sky on That September Morning*, Spencer Finch (American, b. 1962), watercolor on paper, courtesy 9/11 Memorial Museum, photograph by Jin S. Lee.

5. PAPAL VISIT TO 9/11 MUSEUM

On September 25, 2015, Pope Francis visited the 9/11 Memorial and held a service for peace inside the museum (fig. 10). Completion of the remounting project the week before the Pope's arrival allowed the ceremony to take place exactly as planned. The third mounting system has continued to successfully support the entire installation as intended by Spencer Finch, and the artwork has been experienced by over a million visitors since completion of the project (fig. 11).



Fig. 11. Completed installation using third mounting system, *Trying to Remember the Color of the Sky on That September Morning*, Spencer Finch (American, b. 1962), watercolor on paper, courtesy 9/11 Memorial Museum, photograph by John D. Childs.

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6. CONCLUSIONS

Although rare-earth magnets have proven immensely useful in devising safe and effective mounts for many museum objects, there are circumstances in certain environments, particularly involving objects without protective vitrines, when the use of these magnets can be problematic. The location of the 9/11 Museum in Lower Manhattan, where there are a many sources of airborne magnetic particles, made the use of rare-earth magnets inappropriate for certain applications for open display. The original hypothesis that the dust first seen accumulating on the surface of watercolors on open display in the museum was generated by the construction of the museum proved to be incorrect and the problem of dust collection persisted. Testing and observation, as well as a literature search, all demonstrated that iron-containing particles are present in the atmosphere of Lower Manhattan. Rare-earth magnets are capable of extracting these particles from the air and depositing them on the surfaces of mounted objects even when particle concentration falls below detection limits. The problem of accumulation of dust on the surfaces of artworks should always be at least considered when contemplating the use of rare-earth magnets in developing mounts for the display of objects in museum settings. The further experience and problems encountered by the museum in mounting Spencer Finch's installation only serve to emphasize that collections staff should be prepared to confront the unexpected when developing mounting techniques, particularly for large, unframed works of art on open display in only partially controlled environments.

ACKNOWLEDGMENTS

Many people were involved in various stages of this project, but the authors wish to particularly thank Spencer Finch, senior vice president of collections and chief curator Jan Ramirez, senior vice president of exhibitions Amy Weissner, exhibition production manager Emily Cramer, and our many technicians who worked this project, in particular Jonathan Elliott and Virgil Taylor.

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SOURCES OF MATERIALS

24lb White 2 in. × 2 in. Coin Envelope
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JOHN D. CHILDS AND MAUREEN MERRIGAN

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UNINTENDED CONSEQUENCES OF THE USE OF RARE-EARTH MAGNETS IN MOUNTING OBJECTS ON OPEN DISPLAY

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A MATERIAL DISASTER: PRESERVATION OF THE MUPPETS

SUNAE PARK EVANS

ABSTRACT—Jim Henson Legacy donated 19 of its iconic Muppets to The National Museum of American History (NMAH) in 2013. The condition of the puppets varied, but most of them had serious conservation concerns, as they had been actively used in an uncontrolled environment, were constructed with non-archival polyurethane foam, and had been stored without adequate supports. When they were initially made, the foam's inherent vice was not considered to be a problem since the Muppets were not designed to last forever. As polyurethane foam is easily carved and manipulated, it is a favorite material among puppet makers. Lower-density polyurethane foam, also known as Scott foam, was used because it dyes well and easily, and because it looks nice on film. The use of this foam eventually caused many of the Muppets to lose their shape and to become deformed, collapsed, and even torn. This article discusses the condition of the Muppets upon their arrival at NMAH, their conservation treatments, the materials and methods used for the display forms, and other issues encountered during installation of the 2013–2014 exhibition, *Puppetry in America*.

RESUMEN—Jim Henson Legacy donó 19 de sus icónicos Muppets al Museo Nacional de Historia Estadounidense (NMAH) en 2013. La condición de los títeres varió, pero la mayoría de ellos tenían serios problemas de conservación, ya que se habían utilizados activamente en un ambiente incontrolado, fueron contruidos con espuma de poliuretano no archival, y se habían almacenado sin soportes adecuados. Cuando se hicieron inicialmente, el vicio inherente de la espuma no se consideró un problema puesto que los Muppets no se diseñaron para durar para siempre. Como la espuma de poliuretano es fácilmente tallada y manipulada, es un material favorito entre los fabricantes de títeres. Espuma de poliuretano de baja densidad, también conocida como «espuma Scott», se utilizaba porque se tiñe bien y fácilmente, y se ve bien en películas. El uso de esta espuma eventualmente causó que muchos de los Muppets perdieran su forma y se deformaran, se derrumbaran e incluso se rasgaran. Este artículo discute la condición de los Muppets a su llegada al NMAH, sus tratamientos de conservación, los materiales y métodos utilizados para las monturas de exhibición, y otros problemas encontrados durante la instalación de la exposición *Puppetry in America* en 2013–2014.

1. BACKGROUND

The National Museum of American History (NMAH) had a puppet exhibit in the summer of 2006 titled *Muppets and Mechanisms: Jim Henson's Legacy*. This exhibition honored the 50th anniversary of Jim Henson's iconic Muppets. It featured hand-sock puppets, especially from Henson's first television program *Sam and Friends*, which debuted on a local Washington, DC station in 1955 and included the first Kermit made from green wool. That television show introduced the Muppets to the American audience and launched what would become a global phenomenon.

For years before they came to the museum, the *Sam and Friends* puppets had been stored without adequate supports at Jim Henson Legacy (JHL), the organization that oversees the maintenance, restoration, and

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Fig. 1. *Sam and Friends* without supports.

exhibition of the collection owned by the Henson family, so their condition badly needed to be improved for the exhibition (fig. 1). After conservation treatments and the rebuilding of the bodies with archival materials, the puppets were transformed, again appearing alive and animated (fig. 2). With these efforts, the exhibition attracted visitors of all ages and was very successful. JHL was pleased with the outcome of the exhibition, and thus in 2013, decided to donate some of their important Muppets to the museum.



Fig. 2. *Sam and Friends* after conservation treatments.

2. MUPPETS' CONSTRUCTION AND CONDITION

Most of the donated Muppets—such as Miss Piggy, Bert and Ernie, the Swedish Chef, Elmo, Scooter, Cookie Monster, the Count, the Fraggles, and others from Sesame Street—were constructed primarily with polyurethane foam. Unfortunately, this non-archival material has a short life span that leads to major conservation concerns. The most tragic issue for the Muppets in the NMAH collection is that some visible parts were made from polyurethane foam. During their use, this was not considered to be a problem by Henson since the Muppets were not expected to last forever. When one went bad, another one was made.

As polyurethane foam is easily carved and manipulated, it is a favorite material among puppet makers. Lower-density (35 ppi) polyurethane foam, also known as Scott foam, was used for flat areas and parts of faces such as tongues, noses, lips, and other small parts of the body. It was used since it dyes well and easily, and looks nice when photographed or filmed.

Each Muppet was designed to present its unique character through a special outfit, hat, shoes, and other accessories. Face elements such as eyes, nose, lips, and ears are made from different materials. Plastic soup spoons and ping-pong balls were used for eyes, leather shoe soles for the inside of mouths, wood for noses, and fleece or various kinds of fabrics for body skin and costumes. Again, most of the materials used for the Muppets were non-archival, including toxic and strong glues for making shoes. Large T-pins, safety pins, wood dowels, duct tape, bubble wrap, and other similar items were also used.

For the obvious reasons noted above, the overall condition of these Muppets was quite poor. The amount of deterioration on each Muppet varied, but the typical symptoms were stickiness, dryness, sagging, or that the foam was simply falling apart (fig. 3). This degradation process caused many of the Muppets to lose their body shapes and body parts (fig. 4). While the most critical reason for this condition was the use of non-archival materials and supplies, the puppets were also damaged from storage without adequate support. They were also exposed to an uncontrolled environment during filming—intense lighting and warm temperatures. The extreme physical handling during filming only exacerbated the puppets' conditions.



Fig. 3. Foam deterioration: stickiness, dryness, sagging.



Fig. 4. Foam deterioration: the body shape collapsed.

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3. THE PROCESS FOR TREATMENT AND REBUILDING

A major donation ceremony event was planned to receive the Muppets officially from JHL, in addition to an exhibition titled *Puppetry in America*. The exhibit would feature various American puppets over the 160 years covered by the exhibition. Puppets for the exhibition included a shadow puppet, hand puppets, finger puppets, paper puppets, marionettes, a ventriloquist puppet, stop-motion puppets, and the donated Muppets.

Bonnie Erickson, a former puppet designer, puppet maker, and puppeteer, is the executive director at JHL. Erickson played a critical role in providing background information for each Muppet character, including postures and facial expressions. She reviewed each Muppet's condition and explained exactly how each Muppet should look. During the interview, this information was transcribed by Beth Richwine, a senior objects conservator at NMAH, and an intern, Sara Beth Roberts, created photo documentation. These materials were great references for the process. Erickson repeatedly emphasized that the Muppets should be filled with stuffing to resemble the shape of the puppeteer's arm, yet the stuffing should not fit too tightly.

For a costume conservator, constructing and mounting body forms with proper support are routine tasks. However, as the body shapes of Muppets look quite different from those of human beings, it was not easy to visualize the mountings. Even though one Muppet may be bigger and baggier than another, its main body support was a puppeteer's arm.

After understanding the principles, it was necessary to become familiar with each Muppet. This involved watching Muppet shows repeatedly to try to identify their characteristic body shapes and movements, and to pick the most crucial facial expressions. While this was fun at the beginning, it became stressful within the limited time frame. It was necessary to watch the same scene repeatedly until the desired postures were captured.

All of the Muppets' bodies were rebuilt with Ethafoam, a closed-cell polyethylene foam, cut to the size of an arm, padded with polyester batting to form the required shape, and covered with stockinette to hold all the materials in place. Individual heads were carved in various sizes and shapes such as pointed, round, or triangular (fig. 5). The arms, legs, wrists (and sometimes heads), were added to the body using the Loc-Line modular hose system to provide animated expressions. Each length of Loc-Line modular balls could easily be extended and shortened with hose assembly pliers. An aluminum rod was passed through the assembled Loc-Line and inserted about 5 cm into the Ethafoam body in order to control movements (fig. 6). Hands were



Fig. 5. A new body support constructed with Ethafoam.



Fig. 6. Flexible arms constructed with Loc-Line modular balls and an aluminum rod.



Fig. 7. Muslin underpinnings for a nice shape.

another important body part to express animation. Fingers were made from electrical wire because it provided adequate strength and flexibility. Each finger was wrapped vertically with 5 cm strips of muslin to prevent them from slipping out. The fingers were then put inside the fingers of a cotton glove and padded with polyester batting to improve their shape.

Underpinnings made with muslin (fig. 7) were necessary to provide the proper fullness for the body or arms. Finally, a bracket maker created bases with a pointed pole for each Muppet. Bonnie Erickson consulted on each Muppet to determine its final appearance.

4. CASE STUDIES

Among the Muppets, two of the most challenging, the Swedish Chef and Miss Piggy will be described in greater detail.

4.1. SWEDISH CHEF

The Swedish Chef was wearing a chef hat, white shirt, and pink striped apron as he arrived at the museum in plastic wrap. His body was made of polyurethane foam without any rigid support. He was extremely degraded, and his internal structure collapsed as his shirt was taken off (fig. 8). He required major body reconstruction.

A body form with two arms was constructed for the Swedish Chef from Ethafoam and other materials mentioned above. This body form was built with the aim of providing support for the shirt and apron (fig. 9). However, a few critical adjustments were necessary to meet the requirements for Muppet design. According to the information provided by Bonnie Erickson, two puppeteers were operating the movement of this Muppet,

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Fig. 8. The deteriorated and collapsed body of the Swedish Chef.

one for the mouth and the other for the arms. Only the puppeteers' arms were inside the Muppet, so the Swedish Chef was not supposed to have shoulders—only curved arms (fig. 10). The puppeteers were supposed to look at a television monitor on the ground, so the chef's head was always supposed to look down (fig. 11).



Fig. 9. The new body construction for chef, but he is still looking up and has shoulders which later had to be changed.



Fig. 10. Drawing provided by Bonnie Erickson for the chef's proper appearance.



Fig. 11. Final body construction for the chef.

4.2. MISS PIGGY

Miss Piggy arrived at the museum in a cavity-packed box. The polyurethane foam had clearly deteriorated; yellow powder fell off wherever she was moved. Miss Piggy's face was dry and had no resilience, so it was sagging unevenly and the shape was not symmetrical. There were a few cracks at the top of her head and at the edge of her neck. There was a noticeable split from the left corner of her mouth to her nose, and some tears at the corner of the right lip (fig. 12). These splits at the mouth were chronic problems with Miss Piggy puppets



Fig. 12. Tear on Miss Piggy's face.

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because of the way her heavy nose was made. The aluminum rod bracket inside her mouth and the movement of her mouth while performing added to the splits. These repeated splits were well recognized by JHL, but the disposable head was not a serious concern until Miss Piggy became a museum object. The splits required mending for the exhibition because her face is so iconic. The first step was to remove her head from her body, but without knowing her exact internal condition and how she was built, it was difficult to proceed to the next step (fig. 13). Erickson was invited to the museum for a few sessions to help with these types of problems.

A piece of Scott foam was ordered to test how it reacts with adhesives. After testing a few adhesives, BEVA D-8 Dispersion (D8) was selected because keeping a static appearance on Miss Piggy's face was one of the important factors. It provided the best performance without causing any tension on the surface. Other adhesives were so strong that the treated area was somewhat puckered. The D8 adhesive was applied directly to the small splits in Miss Piggy's face, but support foam was necessary to stabilize the larger split at her mouth, since her heavy and bulky nose kept moving back to the original position of the split. A small piece of foam was cut out from the edge of Miss Piggy's neck for this repair because the color and texture matched well to the face. The location for the cutout was not visible since it was under the body form. After the adhesive treatment, flocking fibers were applied to the repaired nose to match the texture of the flocked face. Adhesive was not necessary, as the new flocking fibers could be applied with finger pressure to attach to the existing flocked surface (fig. 14).

5. CONCLUSIONS

JHL and NMAH have their own distinctive policies and philosophies in terms of handling the Muppets, but both have the same goal: presenting the Muppets to the public in the best possible way. The Muppets were originally designed to bring humor and fun to audiences, but the NMAH wants to preserve them as important material objects for future generations to enjoy. The overall condition of the Muppets was poor when they arrived at the museum due to the use of non-archival polyurethane and because they were stored without

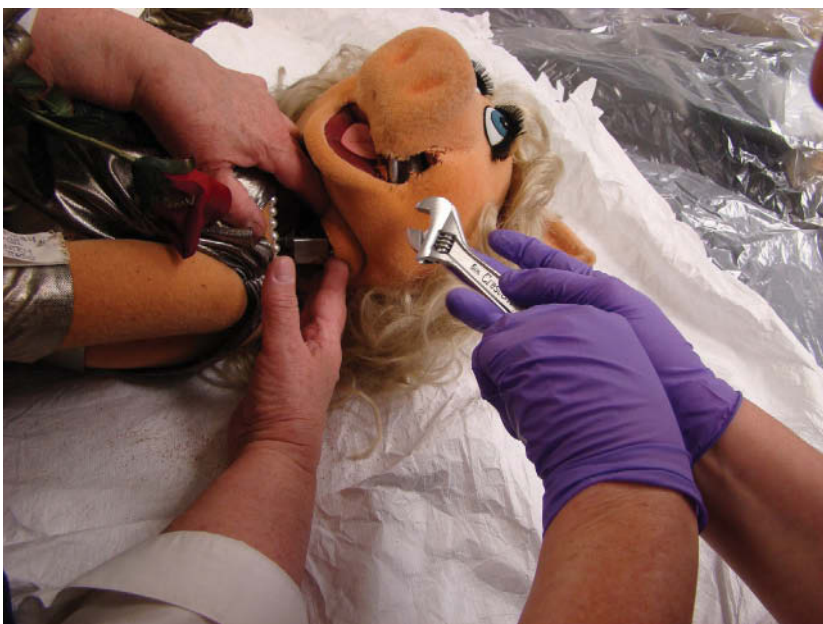


Fig. 13. Removal of Miss Piggy's head for conservation treatment.



Fig. 14. Miss Piggy after the treatment.



Fig. 15. Muppets at the NMAH exhibition in 2014.

the necessary support. NMAH staff applied preventive conservation techniques and methods to ready the Muppets for exhibition while JHL staff contributed their creative designs and knowledge. Collaborative efforts based on combined knowledge, expertise, experiences, and patience were necessary to reignite the most interesting and animated appearances for the Muppets in the final exhibition (fig. 15).

ACKNOWLEDGMENTS

I would like to thank my museum colleagues: conservators, curators, interns, bracket makers, the collections manager, designers, the project manager, photographers, exhibition productions, registration services, and many other museum staff. I would also like to express my respect for Jim Henson's ingenious creations. My special appreciation goes to Jane Henson, Bonnie Erickson, and Dwight Blocker Bowers, who provided their expertise, amazing references, and their fun, patient, and warm hearts to allow these wonderful Muppets to come alive again.

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SOURCES OF MATERIALS

Armature and sculpture wire

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A BIOLOGICAL DISASTER TO COSTUME

MARY BALLARD, LAURA MINA, CATHLEEN ZARET, AND CAROL GRISSOM

ABSTRACT—Natural disasters come in many forms, but rarely is an entire museum's collection inundated with a predatory insect infestation. In the fall of 2006, the Smithsonian's newest museum, the National Museum of African American History and Culture (NMAAHC), requested that the Museum Conservation Institute (MCI) assess and evaluate the condition of the Black Fashion Museum (BFM) in Washington, DC. Its former director and owner, Lois K. Alexander, had traveled the United States collecting garments designed, sewn, and/or worn by African Americans spanning the 19th and 20th centuries; she headed the Harlem Institute of Fashion before founding the BFM and moving the collection to Washington, DC. However, Alexander was now incapacitated; although the family continued to manage the collection, they found it overwhelming. Her daughter sought to donate the collection in its entirety to the new Smithsonian NMAAHC. The BFM filled a two-story townhouse with costume and accessories. When the Smithsonian inspected and evaluated the collection, it was stored in a closed environment and infested with live carpet beetles in all stages, along with spiders. This paper will recount the survey, removal, initial treatment, and rehousing for this stunning collection that took place from 2007–2014.

RESUMEN—Los desastres naturales vienen en muchas formas, pero raramente es la colección entera de un museo inundada con una infestación de insectos depredadores. En el otoño de 2006, el museo más nuevo del Smithsonian, el National Museum of African American History and Culture (NMAAHC), solicitó que el Museum Conservation Institute (MCI) evalúe la condición del Black Fashion Museum (BFM) en Washington, DC. Su ex directora y propietaria, Lois K. Alexander, había viajado por Estados Unidos recolectando prendas diseñadas, cosidas y/o usadas por afroamericanos en los siglos XIX y XX; ella encabezaba el Harlem Institute of Fashion antes de fundar el BFM y trasladar la colección a Washington, DC. Sin embargo Alexander ahora estaba incapacitada; aunque la familia seguía manejando la colección, la encontró abrumadora. Su hija trató de donar la colección en su totalidad al nuevo Smithsonian NMAAHC. El BFM llenaba una casa de dos pisos con trajes y accesorios. Cuando el Smithsonian inspeccionó y evaluó la colección, se almacenaba en un ambiente cerrado e infestado con escarabajos de las alfombras vivos en todas las etapas, junto con arañas. Este artículo contará la encuesta, la remoción, el tratamiento inicial y el re-almacenaje de esta impresionante colección que ocurrió entre el 2007 y el 2014.

1. INTRODUCTION

The Black Fashion Museum (BFM) was founded by Lois K. Alexander in 1979 in New York City as an outgrowth of her Harlem Institute of Fashion (Taylor 1982). Alexander's life work was to shine light on the historic and contemporary contributions made by African Americans to American design and fashion. Overwhelmed with the legacy and its responsibility, her family sought to donate the entire BFM collection and associated archival materials to the National Museum of African American History and Culture (NMAAHC), which opened September 24, 2016 (fig. 1).

The extensive BFM collection has objects ranging from the mid-19th century to the mid-1980s. It contains pieces created and worn by slaves, former slaves who became tailors and designers, and a

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Fig. 1. Lois Alexander with pieces from her collection.

number of 20th century black designers of couture clothing and furs, as well as garments worn by black entertainers and other African Americans from all walks of life (Smaltz 1982). The collection includes a dress that Rosa Parks was working on for herself before her famous arrest in Montgomery, AL, as well as theater costumes from *The Wiz* by Geoffrey Holder and debutante gowns designed by Anne Lowe, the African American society designer who created Jacqueline Bouvier Kennedy's wedding dress (Mitchell, as referenced in Alexander 1982, 22).

In the fall of 2006, NMAAHC requested that the Museum Conservation Institute (MCI) assess and evaluate the condition of the BFM holdings. Alexander had transferred the museum and its contents to Washington, DC (Vermont Avenue NE) in 1994, and now she had become chronically ill and incapacitated (Bailey 2007). When the evaluating team from MCI and NMAAHC arrived at the townhouse, they found the upstairs rooms filled with costume, much of it in open storage; the kitchen area and an upstairs pantry were filled with archives, photographs, and files. There were mannequins in the stairwell and boxes of returned loans in the living room. Apart from a few fold-out chairs in the "dining room" and an upstairs study with a desk and typewriter, the entire house was devoted to black fashion. Unfortunately, MCI discovered an active infestation; throughout the collection were the larvae of what are now characterized as varied carpet beetles, though initially they were thought to be furniture carpet beetles.

Carpet beetles are ubiquitous throughout North America. The varied carpet beetle (*Anthrenus verbasci* L.) and the common carpet beetle (*Anthrenus scrophulariae* L.) are very similar; both are 2 or 3 mm long as adults. The varied carpet beetle has a brownish and yellow irregular (i.e., "varied") pattern on a black



Fig. 2 a-c. From left: a: Furniture carpet beetle (*Anthrenus flavipes*, Le Conte); b: Varied carpet beetle (*Anthrenus verbasci*, Linnaeus); c: Common or Buffalo carpet beetle (*Anthrenus scrophulaia*, Linnaeus). Figure 2c has its wings beginning to open; the others have their wings tucked under.

background on its back; the common carpet beetle also has a black background with whitish small spots and a red-orange strip down its back. The furniture carpet beetle (*Anthrenus flavipes*, LeConte) is the same size. Its back is black with yellow and white scales, though its ventral surface is white. Story groups the varied carpet beetle and the furniture carpet beetle together in terms of bionomics (Story 1985; Black 2004) (fig. 2).

2. BIONOMICS OF CARPET BEETLES

There are four stages in a carpet beetle's life: the egg, the larva (fig. 3), the pupa, and the adult (Story 1985). Carpet beetles are essential to the ecological balance: without them we would be knee-deep in dander, feathers, and decay, but they are a biological menace to clothing preservation. Adults are small and rounded, measuring 3–5 mm, a fraction of the size of a ladybug. They are attracted to spring flowering plants, and eat pollen and nectar. Since they are also attracted to light, adult carpet beetles can often be found near windows, which means their presence can be monitored indoors with unbaited sticky traps laid flat on window sills. Females can lay 30–40 tiny eggs on a food source, such as a dead animal or an object in museum collection storage. Larvae prefer dark secluded places and take anywhere from three to 36 months to develop. They begin to feed as soon as they hatch and are described as “voracious.” They have five to 16 instars (molting up or down) depending on environmental conditions. Larvae will bite anything once, wool or synthetic fiber. The pupal stage takes 12–15 days, and then the cycle begins again (Story 1985; Black 2004).

Carpet beetles are not casual itinerants; the adult female has wings and will fly towards light to find a mate. Certain shrubs and flowers act as hosts for the male and female mating. The female then seeks to lay eggs on a probable substrate. Otherwise, the various stages of the larvae do not stray far from their food source. Oftentimes, an infestation can remain somewhat isolated. However, in this instance, the infestation had spread throughout the building, indicating a long incubation.

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Fig. 3 a-c. Carpet beetle larvae from left: a: Furniture carpet beetle (*Anthrenus falvipes*, Le Conte); b: Varied carpet beetle (*Anthrenus verbasci*, Linnaeus); c: Common or Buffalo carpet beetle (*Anthrenus scrophulaia*, Linnaeus). The size of the larvae will vary with the instar or stage, about 2.5–6.5 mm (up to about ¼ inch long).

3. BLACK FASHION MUSEUM INFESTATION

The most dramatic discovery was an upstairs closet tightly packed with garments adjacent to a sealed walled-up chimney; a pile of red powder was found on the floor beneath a red wool coat. The former chimney may have remained partially or fully open at the roof line so that feathers and nest debris had dropped down. When the food source was depleted in the chimney, some larvae or adults might have found a miniscule crack to reach the red wool coat, eating their way up the hem and around the collection. Larvae cannot digest dye—a small percentage of the weight of the processed wool fabric—hence the small red frass mound below (fig. 4).



Fig. 4. Left: the red coat with insect damaged hem. Right: resulting frass found below coat.

Alternatively, Black Fashion Museum clothing sent on loan might have been returned infested with eggs of carpet beetles. If the loaned clothing were reshelfed or rehung without vacuuming and/or brushing all seams and surfaces inside and out, an infestation might have been introduced that way. In addition, the BFM was developed at a time when clothing accessioned into museum collections was modeled for patrons at annual luncheons—perhaps by one or more of the patrons themselves. Lois Alexander was a principal at the Harlem Institute of Fashion, so some students might well have worn the clothing. Inadvertent staining or soiling from these or other activities can provide essential nutrients for keratin digesting insects.

4. PROTOCOLS

As with other kinds of disasters, only one or two knowledgeable staff members are needed during the initial survey to assess the extent of damage, identify the insect(s), and be familiar with the type of collection affected. The initial responders need to have a general knowledge of costume and fashion history. This initial staff devises a plan of action and goals for treatment. They get approval and authority to purchase supplies, and assemble and coordinate a larger working group.

Unlike other kinds of disasters, a pest infestation can travel home with the responders, replicating the infestation among their own clothes, furnishings, and heirlooms. This disaster can infect their laboratories or studio spaces, or their museum's collection storage. An infestation can also be also passed to friends and relatives, so precautions must be taken.

It pays to be vigilant. Responders should:

- Restrict access to the infestation site.
- Take precautions when leaving the site for work or home.
- Assume *everything* is afflicted, infested, and embedded with larvae and eggs.
- Wear aprons or disposable Tyvek coveralls.
- Bag work clothes at the end of the day as you leave; seal and label the bag. Wipe the bag with disposable towels before bringing it into the home. The bag should be opened directly into the washing machine; after washing and drying, ironing is recommended. A box of unused bags, sealing tape, and a change of clean clothes bagged and sealed should be kept in the car.
- Shampoo and shower after leaving the site.

For the team working at the BFM, there were some advantages—it was summer in Washington, DC, which allowed them to wear washable, non-edible, cotton work clothes and washable sneakers rather than woolen coats or sweaters. The location allowed for the direct order and delivery of all supplies, and there were trucks available for transporting the collection supplies.

There were also some disadvantages to the season. Doors and windows had to be kept closed, and without air conditioning, the urban space became hot and stuffy as the spring quickly changed into summer.

5. TRIAGE AND PACKING

The first steps of the rescue were sorting and packing the collection. All that was needed were a few tables, tissue paper, boxes, packing tape, marking pens for the boxes, a digital camera, and pens and paper to enumerate the contents of each box so the location and objects could be connected (e.g. LR-6 meant Living Room Box 6).

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Table 1. Physical Properties of Argon (Hwang and Wettmer 1995; Merck 2006)

Property	Argon
Atomic number	18
Atomic weight	39.948
Critical point temperature, K	150.86
Critical point pressure KPa and psi	4898 and 710.21
Critical point density kg/m ³	535.7
Normal boiling point, K	87.28
Solubility of gas in water, 20°C, mL/kg	15.759 or 33.6 cc/kg water

After everything was boxed, the infested collection was placed in a truck and taken to MCI located at the Smithsonian Institution's Museum Support Center (MSC) in Suitland, MD for anoxic treatment with argon gas and zeolites. All boxes were removed at one time in order to conform to security protocols; someone stayed with the truck at all times; and the boxes were checked and accounted for.

6. ARGON

Argon is a clear, colorless, odorless gas at room temperature and pressure (table 1). It is characterized as a noble gas; its outer p subshell is entirely filled with electrons, and it is inert, monoatomic, and stable (Merck 2006).

Argon is found naturally among the nine fundamental components of air when freely sampled (table 2), along with four other noble gases in trace amounts.

Argon is commercially available as a compressed gas and is sold with various grades of purity rated from B through F, with E being the purest (meaning the lowest level of $\mu\text{L/L}$ of all contaminants), and with F the lowest with water as a contaminant (table 3).

Argon is used industrially to shield metals from reaction with atmospheric oxygen and nitrogen during heating and melting. With stainless steel, it is employed in the decarburizing process; with other specialty alloys, it is used in refining, casting, and annealing. Argon/nitrogen gas mixtures are commonly used to protect and prolong the life of the tungsten filaments of incandescent lights (Merck 2006). Other applications

Table 2. The Principal Constituents of Air (Hwang and Wettmer 1995)

Gas	Concentration $\mu\text{L/L}$	Minimum work of separation at 300K, kJ/mol	Normal boiling point, K
Nitrogen	780,840 $\pm$ 40	1.68	77.35
Oxygen	209,460 $\pm$	6.11	90.19
Argon	9340 $\pm$ 10	14.11	87.28
Carbon Dioxide	300 $\pm$ 30	22.73	194.67 ^a
Neon	18.21 $\pm$	29.72	27.09

^a Sublimation temperature.

Table 3. Commercial Specifications for Argon (Cady and Cady 1945; Hwang and Wettmer 1995)

Specification	Compressed Gas Association Grades				
	B	C	D	E	F
Minimum purity	99.996	99.997	99.998	99.999	99.9985
Total maximum impurity, $\mu\text{L/L}$	40	30	20	10	15
water	14.3	10.5	3.5	1.5	1
THC ^a as CH_4	5*	3*	0.5	0.5	0.5
oxygen	7	5	2	1	2
nitrogen	15	20	10	5	10
hydrogen	1	1	1	1	1
CO_2	*	*	0.5	0.5	0.5

^a Total hydrocarbons, reported as methane.

*THC measurement includes CO_2 .

include the use of argon as the insulating layer between panes of glass for double-paned windows in commercial and residential buildings (Fisette 1998), permanent wedding dress storage (Rising 2001), anoxic suffocation of insects (Koestler 1992), and mold control and deodorization (Shiner 2007). This last application, deodorization, is carried out in conjunction with zeolites—molecular sieves that have an extraordinary capacity for absorption (Kühl and Kresge 1995).

7. ZEOLITES

Zeolites are microporous crystalline silicates or aluminosilicates that have useful applications as molecular sieves. They trap molecules selectively, based on size and polar properties (Dyer, as referenced in Rempel, 1996). Adsorbed molecules are held in place within the internal cavities of the zeolites by physical and chemical bonding (Hollinger 1994). Thus, sufficiently adsorbent zeolites can function to trap undesirable gaseous chemicals present in an environment, including sulfur dioxide, nitrogen dioxide, acetic acid, carbon disulfide, formaldehyde, and ammonia. Furthermore, zeolites are inert and non-reactive, and therefore suitable for use near objects (Rempel 1996). For argon treatment, a 25 lb. bag of the natural zeolite clinoptilolite was transferred to heavy cotton canvas fabric bags that were open and porous to air but not dust; the bags were placed in each bubble to act as molecular traps for deodorization. The Z-Filter Media zeolites, CAS 12173-10-3, that were used for the BFM collections are not combustible and do not produce hazardous waste; they are routinely used in filtering swimming pools.

8. ARGON “DEODORIZATION” TREATMENT

The boxed garments were placed in two chambers (bubbles) each measuring $8 \times 11 \times 11$ ft. (968 sq. ft.). When treating such an infestation with argon gas, a closed environment with less than 1000 parts per million (ppm) of oxygen present must be maintained for 30 consecutive days to suffocate all stages of carpet beetle activity. Argon is an inert noble gas, and therefore is nonreactive and safe for use with all materials.

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The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) has not received the regulatory documentation for argon to be used as a commercial fumigant for pest control. Technically, a fumigant must be approved for each insect species for which it is licensed. The approval is based on extensive laboratory research and formal experimental work documenting specific dosages for each insect stage. Because argon is a freely available gas, there is no commercial incentive to undergo such expensive testing. Nonetheless, a non-oxygen atmosphere may kill both insects and humans. Hence, the same level of documentation carried out by standard fumigation procedures and the same safety features are required for prudent, successful treatment. What transpires can be referred to as an “argon treatment,” not fumigation. By adding bags of zeolites, this treatment can be formally titled a “deodorization” and eliminate statutory confusion for management and the state agency assigned to enforce pesticide regulations.

Corrugated boxes contain air that must be pumped down several times using a vacuum to reduce the number of argon replacements (fillings) needed to reach the required oxygen level. It is helpful that argon is heavier than oxygen. The object filled boxes are on the ground with the argon, and the oxygen rises above the objects as argon is pumped into the chamber.

Because there wasn't time to test for a lack of oxygen—similar to the atmosphere that causes Prussian Blue to go colorless and vat dyes to go into a leuco, soluble (dye bleeding) state—susceptible textiles including indigo and bright blue cotton upholstery were isolated before being moved from the BFM museum with tissue and/or Ethafoam. After treatment, nothing was seen to have bled or altered in color (note 1).

The cost of argon treatment is roughly comparable to that of sulfuryl fluoride, a common commercial fumigant. Additional savings in this instance were realized by having government workers, interns, and the security guards at the MSC facility already in place. Temperature and humidity were easily maintained, as the building is purpose-built to hold collections, again at no additional cost to the project.

8.1. ARGON TREATMENT SAFETY MEASURES

Once the bubble is prepared, treatment with argon may begin only if all proper safety precautions are taken. Anoxic conditions are deadly to aerobic organisms, including humans. All authors of this paper are or were state-licensed pest control operators (PCOs) in the fumigation category and cognizant of safety training. The indoor air quality monitoring system used in the room manufactured by Yes Environmental Controls could record only levels of carbon dioxide, temperature, and humidity. MCI purchased four, two-year disposable gas detectors (Gas Alert Clip XT Detectors). They were activated and tested to determine the alarm types (loud noise, intermittent strobe flash, and vibration) as well as to confirm oxygen sensitivity. Low-oxygen-level alarms were set to begin below 19.5% by volume. If argon is used on a routine basis, the purchase of a Yes Monitoring System for Oxygen is worthwhile. At least two of the four disposable detectors were kept in the room at all times.

Precautions to ensure safe argon bubble use include the following:

- Treatment requires a minimum of a two-person team during filling and monitoring.
- All staff and technicians working near the bubbles must wear oxygen monitoring devices (dosimeters).
- Oxygen monitors with alarms must be present outside the bubble or chamber.
- Conditions inside the bubble must be remotely monitored using data loggers and oxygen sensors.
- Placards notifying staff of treatment in progress must be posted.

- Doors to the treatment room must be kept closed, locked, and monitored.
- The treatment room must have a land-line telephone if cell phone reception is limited.
- Emergency plans, including evacuation procedures, must be in place.

These safety measures apply to all large-scale anoxic treatments (always have a partner present, always have a cell phone, use oxygen monitors that will sound an alarm if the oxygen level outside the bubbles drops below 19.2%). The room containing the chambers was locked with limited, carded access in a high-security building. MSC guards were present 24/7 outside the area and kept a log book monitoring the presence of staff in the restricted area.

8.2. COMPARISON TO OTHER FUMIGANTS

This treatment was carried out June through September 2007 in order to achieve more than 30 consecutive days of oxygen levels below 1000 ppm (0.1% by weight). The oxygen level was checked and maintained daily. The plastic bubble containers used were meant for use with carbon dioxide, which operates with a more relaxed maximum of 6% by weight oxygen (60,000 ppm). Leakage with carbon dioxide is not as critical as it is for argon. For oxygen levels to be kept below 1000 ppm, the concentration of argon had to be “topped up;” this took two to five hours/day.

There are other anoxic treatments that will stress an insect’s respiration. Carbon dioxide was used for many decades with other restricted-use fumigants as an adjuvant and a means to reduce flammability (Rice 1969). It is licensed as a stored product pest fumigant in the United States and technically is a registered restricted-use product when it is used to eradicate an infestation (EPA 1991, 2016). It is used to control some museum pests in chambers and bubbles; because it is a licensed fumigant, normally operators are licensed. Its limitations may be associated with the chemical reactivity of carbon dioxide, the active ingredient of seltzer water, a mild acid. One advantage is the higher level of oxygen permitted during the operation of the chamber, so that a tight seal and constant monitoring are less important.

Nitrogen has been used both as an initial fill for a vacuum-purged chamber and as an anoxic treatment itself. Again, the cost of nitrogen compressed tanks are less expensive than those of argon, and comparable to those of carbon dioxide. Nitrogen may require a higher temperature (30–40°C rather than room temperature) to insure complete mortality, but like carbon dioxide, a little oxygen (0.4%) does not affect the level of insect mortality (Gilberg 1991). Nitrogen gas should be humidified above its 15%RH for organic material (Valentin and Preusser 1990; Buss and Crews 2000). Nieves Valentin directly compared the efficacy of nitrogen, argon, and carbon dioxide with test insects that included carpet beetles and clothes moths, and found the argon atmosphere produced the best results (Valentin 1993).

9. REHOUSING

After 30 consecutive days of anoxia, the collection was no longer infested. The next step was removing any traces of the insects. The objects required thorough surface cleaning of every nook and cranny to remove frass, carcasses, and cast-off casings. A dedicated laboratory was prepared and stocked with variable-suction vacuums with HEPA filters, micro-attachments and screens, tweezers, and archival storage supplies to receive and prepare the 273 boxes of BFM textiles for survey and rehousing.

There is no residual protection against pests with an argon treatment or with fumigation treatments. In fact, the dead carcasses are an attractive food source to start a new infestation. During surface cleaning,

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it must be kept in mind that adult carpet beetles do not differentiate between fiber types, and new eggs could be deposited anywhere, especially where there are cast-off larval skins edible by any new, live larvae. Moreover, degraded parts of the dead insects undetected or unnoticed by a future conservator could spot-stain or discolor areas during wet cleaning. Thus, *everything* has to be vacuumed inside and out; every layer and ruffle, every interior seam allowance and hem must be turned back and cleaned. Nozzles and micro-attachments must be washed after each use to control cross-contamination. In addition, the laboratory space itself must be cleaned and kept free of debris, and adjoining lab spaces monitored. It is helpful to have someone on hand to develop expertise in diagnosing and repairing vacuum cleaners.

After many hours of surface cleaning and condition documentation, the garments were finally ready for any necessary stabilization and loss compensation, and ultimately for mounting and display in the inaugural exhibits of the National Museum of African American History and Culture.

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NOTES

1. A formal experimental paper on Prussian Blue fading in the absence of light has now been submitted to JAIC.

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A TEXTILE CONSERVATOR'S CONTRIBUTION TO DISASTER PREPAREDNESS AT THE MUSEUM OF FINE ARTS, BOSTON

C. P. IANNUCCILLI

ABSTRACT—This article examines disaster planning at the Museum of Fine Arts (MFA), Boston, through a textile conservator's point of view. It discusses aspects important to both the overall MFA Disaster Preparedness Plan as well as the individual Emergency Action Plans for each of the museum's divisions. These include the influence of FEMA's Incident Command System on the MFA's plan, Human Resources' integration into the Logistics Division of the plan, emergency communication upgrades museum-wide and for members of the emergency response team through the Departments of Information and Protective Services, and most importantly, garnering the fiscal and verbal support of the administration and the MFA community.

The Disaster Preparedness Plan at the MFA is an ever-evolving document that adapts to changing recommendations set forth by museum personnel and government agencies. The Department of Conservation and Collections Management has been an important contributor over the years to the MFA's preparedness goals. This includes establishing and acquiring supplies stored in carts throughout the building, as well as mobile kits carried by the Backpack Team—employees who can be quickly dispatched in response to an incident. Working together has been essential over the years, for both training as well as during individual emergencies.

RESUMEN—Este artículo examina la planificación ante desastres en el Museo de Bellas Artes (MFA), Boston, a través del punto de vista de una conservadora textil. Se discuten aspectos importantes tanto para el Plan de Preparación ante Desastres del MFA como para los Planes de Acción de Emergencia individuales para cada una de las divisiones del museo. Estos incluyen la influencia de la Sistema de Comando de Incidentes de FEMA en el Plan del MFA, la integración de Recursos Humanos en la División Logística del plan, las actualizaciones de comunicaciones de emergencia a través de los Servicios de Información y Protección en todo el museo y para los miembros del equipo de respuesta a emergencias, y lo que es más importante, obteniendo el apoyo fiscal y verbal de la administración y la comunidad del MFA.

El Plan de Preparación ante Desastres en el MFA es un documento en evolución constante que se adapta a las recomendaciones cambiantes establecidas por el personal del museo y agencias gubernamentales. El Departamento de Conservación y Manejo de Colecciones ha sido un contribuyente importante a través de los años a los objetivos de preparación del MFA. Esto incluye el establecimiento y la adquisición de suministros almacenados en carros en todo el edificio, así como los kits móviles llevados por el Equipo Mochila, empleados que pueden ser rápidamente despachados en respuesta a un incidente. Trabajar juntos ha sido esencial a lo largo de los años, tanto para la capacitación como durante las emergencias individuales.

1. INTRODUCTION

The Museum of Fine Arts, Boston (MFA), has always taken disaster preparedness seriously for the security of the treasures entrusted in its care and the safety of its visitors and staff. However by 2001, it had become apparent that the original MFA Disaster Preparedness Plan (1996) and the Disaster Preparedness Committee—both long established at the institution—lay dormant, with the administration showing little interest in their reinvigoration.

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Fig. 1. Aerial view of the MFA and the adjacent Muddy River
(Courtesy of the MFA/Department of Conservation and Collections Management)

Since the MFA is located parallel to the Muddy River (fig. 1) and has on several occasions experienced ground flooding, this was concerning to the conservation staff members who cared for the collection, especially those with lower-level storage areas, such as the collection of Textile and Fashion Arts. It became apparent that collections stored at basement level were, and are, at risk, and that disaster preparedness should always be considered a necessary part of long-term preservation at the MFA.

When on September 11, 2001, planes tragically hit the World Trade Center in New York City, the Disaster Preparedness Committee was quickly re-established. An important lesson was learned at that time: tap into support while you have the attention of those in charge, and whenever possible, use local or national motivation for disaster preparedness to improve the preparedness at your institution. Disaster preparedness is not sexy, and no one really wants to think about it, let alone spend money and time on something that may never happen; but in fact, every one of us needs to.

2. DISASTER PLANNING AT THE MFA, BOSTON

As a unified organization, disaster planning is an additional but necessary task for everyone at the MFA—departments as well as individuals. When the re-established MFA Disaster Preparedness Committee first met in 2001, the primary focus was to edit the existing Disaster Preparedness Plan. This plan has subsequently gone through two major stages. The first stage included edits and revisions to the existing plan, along with the addition of several chapters in the form of Emergency Action Plans (EAPs). EAPs were written for each of the six primary areas of the collection: the Department of Asian, Oceanic, and African Art; Furniture Conservation; Objects Conservation; Paintings Conservation; Paper Conservation; and the Department of Textile and Fashion Arts. These plans serve as both chapters of the overall MFA Disaster Plan as well as standalone documents.

Since 2011, the focus of the second stage of the museum's in-house Disaster Preparedness Committee has focused on improving comprehensive disaster preparedness through planning for disaster scenarios, training exercises for staff, positioning supplies in strategic locations around the museum, and improving in-house communication. Updates and revisions to the MFA Disaster Preparedness Plan have been made to reflect these changes as needed.

The catalyst for the second stage of the plan derived from three presidential directives. Homeland Security Presidential Directive (HSPD)-5 (Bush 2003a), which required the establishment of a single, comprehensive approach to incident management, and HSPD-8 (Bush 2003b), together directed the Department of Homeland Security to lead an initiative to develop the National Preparedness System, a unified approach to “strengthen the preparedness of the United States to prevent and respond to threatened or actual domestic terrorist attacks, major disasters, and other emergencies” (Bush 2003b). Most critical, though, was the publication of Presidential Policy Directive 8 (PPD-8) in 2011, which describes the nation's approach to preparedness as one that involves the whole community, including individuals, businesses, community and faith-based organizations, schools, tribes, and all levels of government—federal, state, local, tribal, and territorial (FEMA 2016b). The National Incident Management System (NIMS) was established as a structural foundation allowing everyone to work together under the National Preparedness System (NPS).

These directives require simple, understandable language, shared goals, and a common incident command structure for all groups during a disaster throughout the United States.

The Federal Emergency Management Agency's (FEMA) Incident Command System (ICS), a fundamental component of NIMS, is defined as:

A management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure. ICS is normally structured to facilitate activities in five major functional areas: command, operations, planning, logistics, Intelligence & Investigations [*sic*], finance and administration. It is a fundamental form of management, with the purpose of enabling incident managers to identify the key concerns associated with the incident—often under urgent conditions—without sacrificing attention to any component of the command system. (FEMA 2016a)

Since the MFA is part of the Boston community and the state of Massachusetts, it is imperative that the organization aligns with FEMA's Incident Command System. As a nonprofit cultural institution, the MFA has a unique mandate: to be concerned about the safety of staff and guests first and foremost, but secondly to focus on the safety of the collections. Since the ICS states that at the time of an emergency, those most qualified to deal with the incident should take the lead and be placed within the official command structure, this created a new leadership model that necessitated the re-evaluation of MFA's incident command structure.

The Disaster Preparedness Committee has tried to align its goals and preparedness structure with that of the NIMS. These include: planning, organizing, supplies, training and certification, on-site exercises, communication, and evaluating and corrective action. This has been illustrated in figure 2.

3. PLANNING

The goal of improving overall planning was achieved through the second stage of work with the MFA Disaster Preparedness document. All edits needed to align with both NIMS and FEMA's ICS mandates. The committee

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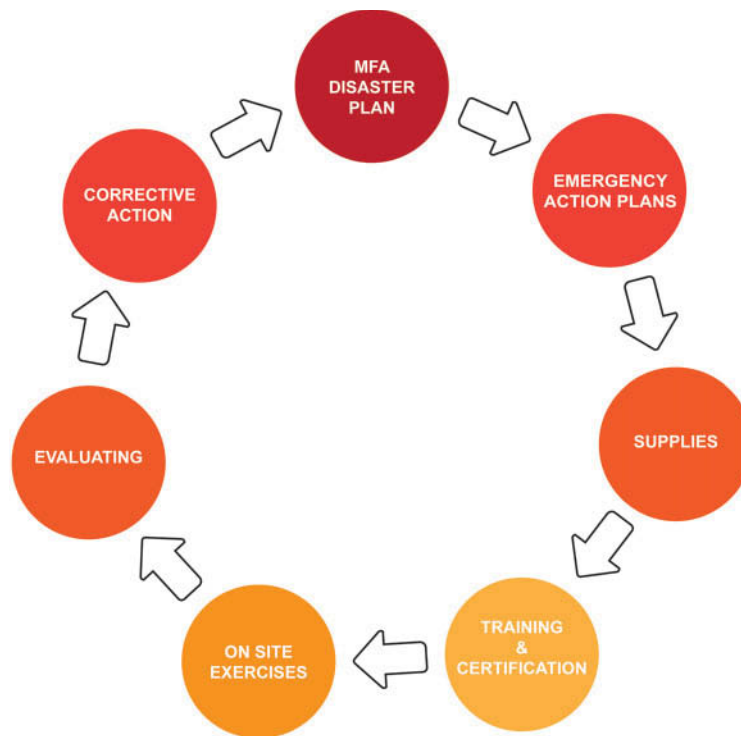


Fig. 2. Illustration of the MFA, Boston's alignment with NIMS

had to go back to the drawing board and not just edit, but rewrite, the disaster plan—still a work in progress in 2016. The MFA team began this round of rewriting with the “Logistics” chapter. Logistics is the organization of the resources and services required to support incident-related activities. This includes coordinating and providing security, facilities, services, and material support for the incident at hand. This chapter, absent from the 2006 plan, was deemed essential to the FEMA ICS and brought the department of Human Resources into the preparedness structure. Human Resources’ responsibilities could include anything from ascertaining the state of the staff directly after an incident, contacting the staff’s family members in an emergency, or organizing payroll for all MFA employees during a recovery. It is important to emphasize that the best way to store and retrieve personal information during a disaster needs to be planned for ahead of time.

4. ORGANIZING: EMERGENCY ACTION PLANS

The goal of an Emergency Action Plan is to prepare responders so that the initial reaction to an emergency or disaster can happen quickly and efficiently. The EAP documents for each museum collection establish necessary supplies and are essential for guiding training exercises within the department. The prototype plan was created for the Department of Textile and Fashion Arts (TFA), since it is the division of the museum with which the author is most familiar. The Textile Conservation area is unique at the MFA because it works closely with the curatorial staff of TFA and has always been located in the same area of the building; therefore, the plan includes both departments. The initial plan was sent to all members of Textile Conservation and the Department of Textile and Fashion Arts in order to solicit constructive feedback.

Once the EAP was completed, it was sent to the other conservation divisions to serve as a model for their own plans. Over the years, the EAPs have achieved a balance between content that is unique to each collection

using standardized text and consistent formatting between all plans. Because first responders to a disaster may not be familiar with the affected collection, it is important that they be able to turn directly to the needed information. Standardization makes staff across the museum instantly familiar with all of the plans.

The documents include immediate, pointed advice based on situations that may be encountered. Disasters make it difficult to think clearly, therefore the EAP “Guidelines” section has been set up with quick, bold bullet points such as, “Aged fibers are weaker when wet!” and, “If you are dealing with soot, don’t touch the textiles!” The guidelines for each collection are stored in supply carts throughout the building for easy access and retrieval.

Keeping up with needed EAP updates and maintaining an accurate inventory of cart supplies has proven to be a challenging task; therefore, an individual has been appointed for each conservation division as an emergency preparedness coordinator. Their duties include keeping the EAPs updated for their respective collections and regularly updating telephone numbers on the emergency contact lists for each division. Emergency preparedness coordinators keep the supplies on emergency carts located in their specific laboratories and storage areas inventoried and updated, and make recommendations for supplies located at off-site storage areas as well as in locations around the MFA where their specific collections would need attention during an emergency or disaster recovery. They also maintain the Conservation and Collections Management (CCM) disaster recovery resource folder specific to their area of expertise, keeping it active and updated with articles and websites focusing on disaster recovery.

This computer folder is designed primarily as a shared resource for CCM staff. It is never certain who will be available during a disaster and/or recovery, so it is recommended that staff members take time to learn the protocol and procedures for other areas of expertise, not just their own. This folder is located in the CCM shared network drive and allows each laboratory to determine what they believe to be best practices and procedures. With so many resources available in print and online, the hope is that only those articles and websites chosen by the specific laboratory to be included in their folder will be used as references to help understand recommended procedures during an emergency situation.

5. SUPPLIES

5.1. DISASTER SUPPLY CARTS AROUND THE MFA

Supplies and carts (fig. 3) were purchased and placed throughout the MFA with the help of some dedicated staff members. Each cart is stocked with flashlights, protective clothing such as disposable gloves and Tyvek suits, first aid kits, tool kits, and tools for documentation such as notebooks and labels. These supplies were acquired in the Disaster Preparedness Committee’s early years (2002–2003). Additional carts have been added since then.

5.2. MFA BACKPACKS AND BACKBACK TEAM

More recently, the MFA Emergency Backpack Team was established. The Backpack Team includes Protective Services, Facilities, and CCM staff—those who will be first to re-enter the building during or after an emergency. Supplies carried in backpacks allow them to go directly where needed (fig. 4).

Guidelines needed to be established as to where the backpacks were to be kept. There could be no single set location, because you never know where you will be when disaster strikes. At the MFA, backpacks are kept within easy reach of team members’ workspaces unless they are taken home due to a forecast emergency, such as a hurricane or blizzard. They are to be worn by the employee during evacuations of the building, even if it is just a drill. Each employee is responsible for the inventory of their personal backpack; this includes keeping flashlights and other electronics in working order. Backpacks are the property of the MFA, but employees are encouraged to add their own items such as personal protective equipment.

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Fig. 3. Disaster emergency carts like this one are placed throughout the MFA, Boston



Fig. 4. MFA emergency backpack with supplies

5.3. EXTERNAL RESOURCES

In addition, the museum is part of the “Code Blue” program run by Polygon, a global recovery company that specializes in drying technologies and climate control solutions. Being part of this program allows quick access to climate control equipment needed to stabilize the museum environment, as well as assistance with any freeze-drying needs resulting from a water-related disaster.

6. TRAINING AND CERTIFICATION

Soon after the MFA Disaster Preparedness Plan was completed in 2006, Barbara Roberts, a disaster specialist and consultant, was brought in for one week to train the museum's entire staff. Training included an all-staff lecture as well as a half-day workshop for the senior management, including the then-director, Malcolm Rogers. Since her visit, the staff has continued to have evacuation drills—some of which were not actually practice, such as those resulting from kitchen-related emergencies in the museum's four food service areas. Recently, a one-day training session was offered for members of the Emergency Backpack Team, led by the consultants Barbara Moore and M. J. Davis.

Nearly every year there is some type of training. One example was an in-house program in 2013 for Heritage Preservation's "Do One Thing for Emergency Preparedness. At re-entry following evacuation, staff received radio communication devices and proceeded to the galleries, where contact was made with base command, as would be the procedure when staff is allowed to re-enter the building after a disaster. This training session ended with the group then touring all disaster supply locations as a refresher.

All staff that may be needed during a disaster are encouraged to take part in the Respirator Certification Program offered at the museum through U.S. Compliance Corp., an occupational safety company. Staff are also encouraged to take advantage of FEMA's free online classes including "Introduction to Incident Command System" (ICS-100) and "National Incident Management System, an Introduction" (IS-700) (FEMA 2016c).

7. COMMUNICATION

The MFA's Protective Services department has drastically improved communication in the event of a disaster with the installation of the Rave Alert Emergency Notification System, offered through the company Rave Mobile Safety. This system allows for immediate communication through e-mails, texts, and voice alerts to provide instructions before, during, and after a disaster. With money from the MFA's disaster budget, Protective Services has also installed a radio communication system for Disaster Preparedness Team members during internal emergencies. This system is the same as that used by Protective Services staff. The radios are always charged and ready, and have a designated channel for use during a disaster. Once allowed back into the building, a staff member or team will be given a radio to use to communicate with Incident Command. The Information Services department also arranged an extranet site specifically for communication between members of the Disaster Preparedness Team. This site is used primarily for the sharing of documents, both during their editing phase and for easy retrieval later.

The Protective Services and Facilities departments continue to establish and nurture relationships with local and state agencies including fire, police, and city building officials. Matthew Siegel, the present head of CCM, keeps in contact with members of the Coordinated Statewide Emergency Preparedness (COSTEP) Framework, an emergency response planning tool for the cultural community in Massachusetts, and regularly keeps staff informed of forecast weather-related emergencies.

8. CONCLUSIONS

Since its inception, the Disaster Preparedness Committee's goal has been to further the ability of the MFA, Boston to be prepared for an emergency or disaster, in order to best protect its daily visitors and collections. Persistence in soliciting the continued support of staff, especially those at the top level, is absolutely necessary, as preparedness is a team effort that requires participation by all departments. It is a top priority to actively embrace and incorporate the ideas of staff members into the disaster preparedness strategy.

As a contributing member of the disaster team, the author has been able to influence some of the more practical, collection-focused aspects of disaster preparedness, and strives to keep disaster preparedness at the forefront of the Conservation and Collections Management department. CCM has been able to ensure that Emergency Action Plans stay updated, that supplies continue to be purchased and placed around the building, and that training is carried out each year. Unfortunate events such as the Boston Marathon bombings are close to heart, and often reinforce the importance of this work at the management level. While no one knows when the next disaster will occur, the continued adaptation to change, consistency in training, purchasing of supplies, and the promotion of awareness within the staff will ensure that the MFA is prepared.

ACKNOWLEDGMENTS

I would like to thank my colleagues at the MFA, Boston, including members of Conservation and Collection Management and members of the Disaster Preparedness Committee, especially Nicki Luongo, director of Protective Services and our incident commander. A special thank-you to Joel Thompson for all her wonderful editing help with this paper. My ability to continue to learn and train has been aided by my membership in the AIC's National Heritage Responders (NHR) and the excellent direction given to all Americans through FEMA. Everyone reading this article should try to take full advantage of this training.

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RESOURCES

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15 Sharpner's Pond Road, Building F

North Andover, MA 01845

Tel: (800) 422-6379

www.polygongroup.us

Rave Mobile Safety

492 Old Connecticut Path

Framingham, MA 01701

Tel: (508) 848-2484

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ASSESSING COLLECTION EMERGENCY TRAINING AND RESPONSE: THE RISKS OF ADRENALINE

LOIS OLCOTT PRICE AND JOELLE D. J. WICKENS

ABSTRACT—Most disaster training programs begin with fairly extensive instruction in planning and preparation. Then they briefly discuss assessment before moving forward to what many regard as the heart of the program: recovery and salvage. A hands-on drill of varying length, complexity, and intensity is often the climax of the program. After designing and implementing many of these programs and drills, the authors have reached the conclusion that an overemphasis on recovery often minimizes the role of assessment, communication, team structure, and function, derailing an effective response and causing additional collection damage and dissociation.

Creation of a graduated, three-session training program that introduces responders to assessment and emergency response in a structured manner designed to reduce stress while improving confidence and decision-making capacity has proven effective. The emphasis on assessment has also enhanced team development and effective communication. This article includes teaching guides, supply lists, checklists, and sample scenarios.

RESUMEN—La mayoría de los programas de capacitación para enfrentar desastres comienzan con una instrucción bastante extensa en planificación y preparación. Luego discuten brevemente la evaluación antes de avanzar hacia lo que muchos consideran el corazón del programa: recuperación y rescate. Un ejercicio práctico de diversa longitud, complejidad e intensidad es frecuentemente el punto culminante del programa. Después de diseñar e implementar muchos de estos programas y ejercicios, los autores han llegado a la conclusión de que un exceso de énfasis en la recuperación a menudo minimiza la importancia de la evaluación, la comunicación, y la estructura del equipo y su función, descarrilando una respuesta efectiva y causando daños de recolección y disociación adicionales.

Le creación de un programa de capacitación de tres sesiones que presenta la evaluación y la respuesta de emergencia de una manera estructurada diseñada para reducir el estrés y mejorar la confianza y la capacidad de toma de decisiones ha demostrado ser eficaz. El énfasis en la evaluación también ha mejorado el desarrollo del equipo y la comunicación efectiva. Este artículo incluye guías de enseñanza, listas de suministros, listas de verificación y ejemplos de escenarios.

1. INTRODUCTION

Most disaster training programs begin with fairly extensive instruction in planning and preparation. They then briefly discuss assessment before moving forward to what many regard as the heart of the program: recovery and salvage. A hands-on drill of varying length, complexity, and intensity is often the climax of the program. After designing and implementing many of these programs and drills, the authors have reached the conclusion that an emphasis on recovery while minimizing the role of assessment, communication, team structure, and function can derail an effective response and cause additional collection damage and dissociation.

Establishing a functional team and effective communication methods comes first. Without this foundation, assessment and recovery that is successful for both people and objects is rare. Assessment should occur before recovery begins and at regular intervals as the response continues. It identifies the nature and scope of the collection emergency and coordinates the resources, documentation, and strategies necessary for each

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stage of an effective response. When these steps are truncated or ignored, even in a drill, chaos often ensues. Too many anxious and adrenaline-soaked responders rush in to save the collection. They get in each other's way, forget the need for documentation, and move objects without adequate regard for priority, condition, risk, or appropriate destination.

This paper outlines a graduated, three-session training program that introduces responders to assessment and collection emergency response in a structured but flexible manner designed to reduce stress while improving confidence and decision-making capacity. This approach has been developed and tested over several years, and has proven effective with students and cultural heritage staff from diverse backgrounds. Because each responder's foundational knowledge, experience, collection familiarity, and emotional response to a collection emergency varies, this training should be tailored to the participants, whether they are students, cultural heritage professionals, or volunteers.

2. HISTORY

The Winterthur Museum, Garden and Library has had a disaster plan in place for decades. The plan is updated regularly and the Collection Emergency team, consisting of conservators, registrars, art handlers, preventive conservation aides, exhibit staff, curators, and interpretive staff, meet twice annually to train. Training usually consists of rotations through conservation laboratories to practice handling and moving damaged objects, presentations on responses to disasters in other institutions, and discussions of various possible scenarios at Winterthur. Twice in the last several years, the Collection Emergency team has conducted comprehensive mock-up drills with expendable objects and a full scenario involving extensive water damage—the museum's biggest risk given the nor'easters that batter the nearby coast as well as increasingly violent thunderstorms.

These large drills typically involve 40 or more staff, each assigned to a functional team and given an outline of their duties in advance. Drills are held in one of the barns on the estate and involve hundreds of expendable objects including books, documents, and photographs on simulated library shelving. Faculty have conducted smaller but equally intensive drills for the first-year conservation students, complete with muddy water from the creek and demanding role-players representing panicked curators and clueless members of the press.

In assessing whether these very time-consuming and intensive drills have been effective training exercises, the authors have found mixed results. Many participants demonstrated good skills in handling, moving, and packing damaged objects. They truly understood the recovery portion, and once a response reaches that point, these are the type of people that are needed. But there seemed to be a battle between adrenaline-pumped responders intent on moving objects as quickly as possible, and the documentation team assigned to record each object as it was removed from the disaster site. Lost in the middle was time for assessment: triage decisions of what to pack for storage, send for immediate treatment, freeze, or dry passively.

The initial assessments by the assigned teams were frequently rushed to accommodate the eager responders gathered nearby and the illogical sense of urgency that prevailed. These were scheduled drills, but many participants experienced an illogical sense of urgency. There was no immediate threat to many of the expendable objects beyond the damage that had already occurred, but the pressure to do *something* was palpable. The pressure in a real event would be much more intense. The sketchy plans developed by the assessment teams involving the orderly removal of objects most at risk often degenerated within the first 15 minutes as objects of all types streamed out the door past sometimes frantic documenters with clipboards. All objects were moved whether they needed it or not. The assessment teams were reassigned to other teams, and coordination fell to each functional team.

Feedback from participants was also mixed: satisfaction and relief that all the objects had been removed and packed, frustration with the documentation process from both sides, and stress from what often felt like a chaotic situation where lines of communication sometimes broke down and anxious teams with different assignments found themselves at odds.

It became clear that a piece of the training puzzle was missing—effective, ongoing assessment and coordination, so a variety of manuals and training programs for disaster response were consulted. Assessment of the emergency site is always noted as an important component of any response effort—one that is critical to planning an effective response—but there is limited information on exactly how it is accomplished and almost no information on specific training. And understandably—for a museum or library's staff, teaching and planning for the safe handling of damaged objects is far easier than teaching decision making and planning in a crisis. A wet book is a wet book—that is a constant. The emergency situation and context in which the book resides is a major variable from one institution and situation to another, and assessment is the tool that is needed.

To develop a training program, the first step was to define assessment and the responsibilities and composition of an assessment team, and then to identify the procedures and tools they would need:

- An assessment team is responsible for assessment and coordination throughout an event, *not* recovery. The team is responsible for:
 - Gathering information and decision making at each stage of recovery
 - Communication with and coordination of other teams
 - *Not* assisting with documentation, object movement, triage, or stabilization
- An assessment team needs member(s) to fulfill the following functions and identify resources needed for each function:
 - Conservation—assess object damage and vulnerability
 - Registration—assess documentation needs and object movement
 - Curatorial—set overall object priorities
 - Support services (art handler/preventive conservation)—assess object movement logistics, and determine equipment and supply needs

After working through these definitions, checklists, documentation kits, and procedural flowcharts for the assessment team were created. Finally, through trial and error, a method was developed for incorporating assessment and coordination into the overall collection emergency training program.

Creation of a graduated, three-part training program has evolved over the last few years. It introduces responders to assessment and emergency response in a structured manner designed to reduce stress while improving confidence and decision-making capacity. Sessions build from low stress to medium stress, from only talking to talking and doing, and from activities that only require imagination to those that also require the implementation of previously learned knowledge.

3. SESSION 1: TABLE TOP EXERCISE

The training cycle starts with an exercise that only requires sitting at a table and talking in a quiet room in the presence of a moderator.

Each participant receives a business card that assigns an institutional role—head of housekeeping, director of marketing, director of public programs, registrar, director of human resources, curator, director of

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public safety, etc. The exact positions are variable to suit any institution, but they should represent all the different functions of the institution, not just those normally associated directly with the collection. Participants also receive a description of the imaginary museum at which they now work—this can be adjusted to fit an institution of any size or type.

After a few minutes, the phone rings and the participant who answers is notified of a collection issue reported by an on-site observer—it may be dripping water, or they may notice the smell of smoke or a moldy smell in a storage room. The scenario is variable, but it should be something fairly modest in scope.

For the next 15 to 20 minutes, participants develop the story, finding their way from the initial discovery to recovery. The primary goal is for participants, at each step of the scenario, to consider who else needs to be brought into the process. By assigning roles ahead of time, participants assume that every person at the table has a part to play; they begin to think about what knowledge others at the table have, as well as reasons why they might need to be notified and updated regularly. The moderator may offer guidance to help keep the process on track and prevent major omissions. After the role-play ends, the moderator conducts a debriefing and review of the session.

No objects are damaged in the process, there are no physical demands on the participants, and no specialized knowledge for assessing or moving damaged objects is required. Participants leave understanding just how many people have a stake in the process and how many issues should be considered when an emergency occurs.

See Appendix 1 for full instructions for the exercise, including sample cards, a teaching guide, and scenarios.

4. SESSION 2: ASSESSMENT IN THE COLLECTION

After the table top exercise has introduced responders to the collection emergency response process, training moves on to assessment and planning. Since the goal is to focus on assessment, all the normal recovery/object handling components were removed from this training exercise, but the exercise still takes place in the collection, so it introduces some of the urgency and adrenaline-inducing object damage typical of major collection emergencies. Using a scenario developed for a specific collection area or building, paper labels identifying hazards (broken glass, mold, wet floors) and object damage (broken, wet, sooty) are placed in appropriate locations. The scenario should not include an active emergency such as an unextinguished fire or gushing pipe. The monitor for the training exercise role-plays as the emergency site manager. To begin, the assessment team gathers in a quiet room separate from the collection emergency area. Participants are assigned to the four major team roles—conservation, registration, curatorial and support services—and given job descriptions. The site manager, using the scenario, briefs the team and provides copies of all checklists, flow sheets, communication trees, etc.

Using the information provided and answers to questions they may ask of the site manager, the team produces an initial assessment plan and a list of resources they know they will need. They communicate this to the site manager by phone or radio, and then proceed to the collection emergency site. Once there, they refine their assessment and lists of needed resources, communicating as necessary with the site manager, who reports on progress in implementing the team's requests for specific resources and asks leading questions to be sure the team is considering all options. The assessment team does *not* undertake recovery or documentation activities. After assessing collection damage, the team returns to the quiet meeting room and is debriefed by the emergency site manager who reports on the availability of requested resources and asks more questions as necessary. Finally, the team produces an outline plan for this emergency response: sequencing needed activities, resources, and coordination responsibilities (documentation, object movement, condition assessment) each team member will fulfill. After the exercise ends, the moderator conducts a debriefing and review of the session.

Participants in this training exercise have found that not being allowed to stabilize or move objects at once was frustrating since the most immediate and urgent response was to *do* something. But during the course of the session, each recognized that what they thought needed doing initially changed as they worked together to assess the situation and plan the recovery. Some initial responses would have been ineffective or counterproductive, or resulted in increased object risk.

See Appendix 2 for full instructions for the exercise, including sample scenarios, a teaching guide, and checklists.

5. SESSION 3: ASSESSMENT AND RECOVERY WITH WET OBJECTS

Only after participants are familiar with the overall collection emergency response and can implement assessment and coordination procedures are they introduced to damaged objects. This session provides a structured introduction to wet objects and their recovery.

The session begins with a series of large foil trays, each filled with a single type of dry object (books, metal objects, textiles, etc.). The objects are examined before wetting and participants are asked to identify their vulnerabilities as dry objects, and predict how they might change once the objects are wet. Then water is added to the trays, wetting the objects, which are allowed to soak for a few hours or overnight. Alternatively, duplicate trays of similar objects that have already been soaking can be introduced immediately. Participants then examine the wet objects and consider which assumptions they made were correct and which were not.

The session instructor then uses the wet objects to teach a hands-on session about handling different types of wet and damaged objects and preparing them for movement, packing, or treatment, repeatedly stressing the vulnerabilities the participants have identified.

Finally, participants form assessment/recovery teams of five to six members to work through the process of recovering trays of mixed objects. Before the recovery process begins, each team assigns roles including leader, recorder, photographer, supply officer, object assessor, and object handler, and reviews the checklists and resources provided. Teams are also reminded of the planning and coordination issues introduced in the assessment exercise and then asked to apply everything they have learned.

Ideally, participants will think about communication, assessment, and planning before active recovery begins, but invariably, some of what they learned in previous exercises is overwhelmed by a sense of urgency and the immediacy of wet objects. Seeing objects that are wet and damaged, even in a training exercise, activates stress and an adrenaline response among those who love objects and work with them daily. But gentle reminders restore calm and the recovery is generally quite smooth and productive. As with the other exercises, the instructor conducts a final debriefing and review of the exercise.

See Appendix 3 for full instructions for the exercise, including a supply list and teaching guide.

6. CONCLUSIONS

Collection emergency team members who are trained and prepared to provide ongoing assessment and coordination are critical to a safe, effective, and well-planned response. Drills and workshops that emphasize the hands-on recovery of damaged objects have overshadowed specific training for this function. Recognition of the importance of the assessment function inspired the development of effective training strategies that improve participants' confidence and effective decision-making capacity, while decreasing stress and enhancing teamwork and communication.

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LOIS OLCOTT PRICE is the recently retired director of conservation at Winterthur, where she managed the conservation, research, and preventive activities for the museum and library, and promoted conservation outreach. She continues to serve as adjunct senior conservator and as affiliated assistant professor in art conservation for WUDPAC. She has graduate degrees from the Winterthur Program in Early American Culture and WUDPAC, where she specialized in paper and library materials. She also worked for 13 years at the Conservation Center for Art and Historic Artifacts in Philadelphia. Her recent book, *Line, Shade & Shadow: The Fabrication and Preservation of Architectural Drawings*, won the 2011 Historic Preservation Book Award, and she is currently involved in training cultural heritage professionals in Iraq. Email: loprice@yahoo.com. Address: Winterthur Museum, 5105 Kennett Pike, Winterthur, DE 19735.

APPENDIX 1

Collection Emergency Assessment and Response Training Session 1: Table Top Exercise

Scenario created by Gregory Landrey, Winterthur Director of the Library, Collections Management, and Academic Programs and Affiliate Associate Professor for the Winterthur/University of Delaware Program in Art Conservation

Scenario written up for distribution by Dr. Joelle D. J. Wickens, Conservator, Preventive Team Head, and Affiliated Assistant Professor for the Winterthur/University of Delaware Program in Art Conservation

Exercise Purpose and Goals:

This exercise introduces participants to the variety of people who need to be included in a collection emergency assessment and response event. It offers an opportunity to think through the communications and actions that are necessary in a particular situation. If appropriately facilitated, it will open participants' eyes to the wide range of people who need to be involved and the large number of actions that need to be initiated before actual response and recovery begins. It is a "talking heads" role-play; the whole scenario takes place sitting in a circle, and there is no actual physical response to an emergency. It is designed to be brief, low risk, and low stress.

Essential Elements:

- A facilitator who has full knowledge of how the exercise should run and what the key learning opportunities are
- Participants who actively assume their assigned roles and create scenarios and responses which are realistic for someone in that role

Group Size:

This exercise is designed for 13 participants and a facilitator. If your group is larger, split into groups of 13 or less. If the group is smaller than 13, you will need to double up on roles.

Materials Needed:

- A set of business cards for each group (see below)
- Copies of the description of The Pierce Museum and Library; one for every two group members is fine
- A circle of chairs, one for each participant, which may or may not be around a table
- Phones for the facilitator and one member of the group

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Exercise Description:

Participants will be assigned a position in a fictitious institution, The Pierce Museum and Library. One member of the group chosen randomly will receive a phone call that reports a possible collection emergency event in the institution. The person receiving the call tells the whole group what was said by the caller and then decides what action (s)he will take, and does so, verbally. Future actions build from this with the facilitator letting the exercise evolve. Redirection by the facilitator may take place in order to make sure key learning opportunities arise.

Facilitator Instructions:

Prior to the exercise:

- Print out a set of business cards and The Pierce Museum and Library description (see below).
- Find a quiet room with space for a circle of 14 chairs.
- Make sure you have the mobile phone number of at least one exercise participant and make sure that person brings their phone to the exercise.

Carrying out the exercise:

1. Have participants sit down and then briefly describe what will take place over the next 45 minutes or so. Include the information that for the purpose of the exercise the time and day in the imagined scenario are the same as whatever time and day you are carrying out the exercise.
2. Tell participants you have good news—they are all now on staff at The Pierce Museum and Library in Coldsville, New England. Pass out the descriptions of The Pierce Museum and Library and give them time to read it. While they are reading, pass around a "hat" with the 13 business cards in it. Have each person blindly draw a card. If there are fewer than 13 participants, pass the hat again so people can draw a second card.
3. Have participants introduce themselves by new name and title.
4. Remind participants that this role-play will be discussion only, not an actual physical exercise. Then tell them something is about to happen. They should wait for a stimulus and then respond.
5. You, as the facilitator leave the room, wait about 30 seconds and then call the person you have made sure brought his/her mobile phone. Say the following: ***This is Greg, I work in the museum café. I don't know if you're the person I should be calling, but I***

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found your number on the museum's website on my phone. I just walked through the second-floor textile gallery. There was water dripping from the ceiling and I'm pretty sure I smelled smoke. You can wait for the person you called to ask questions, but your answers should be "I don't know" and before long you should get off the phone saying you need to get back to work.

6. Wait another minute and then return to the room, taking your seat in the circle. Silently observe the process, letting it go on for a maximum of 15 minutes. In order to keep the scenario developing, it may be necessary for you to ask people if they have been contacted yet, or suggest that someone might want to look into something, etc.
7. After 15 minutes, bring the role-play to a close. Spend another 15 minutes debriefing, using the following questions as discussion starters:
 - a. Were you surprised by anything?
 - b. Was there someone who needed to be involved that you hadn't anticipated would have a role in emergency assessment and response?
 - c. Who should have been brought into the situation sooner?
 - d. Was there anything else you should have done before starting to respond to the situation?
 - e. What did you learn about what needs to be in place in order to be more prepared to respond to an emergency?

APPENDIX 1

The Pierce Museum and Library

Coldsville, New England

The Pierce Museum and Library is known primarily for its collection of decorative and fine arts from around the globe. In addition, it takes great pride in its rare book collection on design, and displays select volumes regularly. The PML is responsible for approximately 100,000 objects in the museum collection and 200,000 volumes in the library. There are 30 galleries and rooms with about 30,000 square feet of exhibit and storage space. It is an old building dating from the early 20th century with numerous additions. The entrance seen here dates from 1960. There is a full-time staff of 60 and it is open to the public year round. The PML has an annual visitation of around 80,000 and depends heavily on admissions for its revenue. Many of the exhibits in the galleries are loan exhibits.



APPENDIX 1

PRINT AND CUT INTO BUSINESS CARDS

The Pierce Museum and Library
Caldsville, New England

Carol
Head of Facilities
carol@pml.com

The Pierce Museum and Library
Caldsville, New England

Philip
Head of Housekeeping
philip@pml.com

The Pierce Museum and Library
Caldsville, New England

Andy
Associate Librarian
andy@pml.com

The Pierce Museum and Library
Caldsville, New England

Katie
Director of Exhibitions
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The Pierce Museum and Library
Caldsville, New England

David
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The Pierce Museum and Library
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Juan
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The Pierce Museum and Library
Caldsville, New England

Judy
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judy@pml.com

The Pierce Museum and Library
Caldsville, New England

Margy
Director of Marketing
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The Pierce Museum and Library
Caldsville, New England

Faith
Director
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The Pierce Museum and Library
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Anne
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Nicky
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The Pierce Museum and Library
Caldsville, New England

Bob
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The Pierce Museum and Library
Caldsville, New England

Dana
Human Resources
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APPENDIX 2

Collection Emergency Assessment Training Session 2: Assessment in the Collection

Scenario created and written for distribution by Lois Olcott Price, Adjunct Senior Conservator, Winterthur Museum, Garden and Library

Exercise Purpose and Goals:

This exercise focuses participants familiar with general collection emergency and response procedures on the assessment function as the key to a safe and effective response. It offers an opportunity to think through the planning, documentation, and communications that are necessary in a particular situation. If appropriately facilitated, it will help participants develop the skills and insights needed to plan and coordinate a response effort. The emphasis is on actions and plans that need to be initiated *before* actual response and recovery begins. The exercise takes place in a collection environment, but there is no actual physical response to an emergency. If held in the participants' home institution, the presence of a collection in which they are invested that suffers even imaginary damage may induce moderate stress.

Essential Elements:

- A facilitator who has full knowledge of how the exercise should run and what the key learning opportunities are
- Participants who actively assume their assigned roles and create scenarios and responses which are realistic for someone in that role

Group Size:

This exercise is designed for four to 13 participants and a facilitator. If your group is larger, split into groups of 13 or less. Each group requires a separate collection area and meeting room.

Materials Needed:

- Copies of the scenario for the exercise, Assessment Team Flow Chart, checklists (Health & Safety, Assessment, and Resources), and the collection emergency manual for the institution if one exists
- Clip board and pencil for each participant
- Signs and pictures that describe specific collection damage and hazards (see below)
- A phone, radio, or walkie-talkie connecting the participants with the facilitator

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Exercise Description:

Each participant will take one of four roles—conservator, curator, registrar, or art handler/support staff. This can be done randomly, or the facilitator can assign participants so their role corresponds to their skills or position. Badge each participant with his/her function. The exercise begins in a meeting room. After the participants have collectively read the scenario, they should consult the Assessment Team Flow Chart and checklists, then discuss how they will do the assessment before leaving for the collection emergency site. After visiting the site, they will return to their meeting room and plan the response using the information they have gathered. The facilitator will act as site manager. The leader of the team or his/her designee will report to the site manager at appropriate times during the assessment. The facilitator may contact or redirect the participants as needed to make sure key learning opportunities arise.

Facilitator Instructions:

Prior to the exercise:

- Design a scenario specific to the group, institution, or learning goal, or use one supplied below. Because this exercise is focused on planning rather than physical action, the scenario should not include active damage such as a pipe that is still spraying water onto a collection. Each scenario should include at least one health and safety hazard, a problem to discover in an additional area not initially reported in the scenario, and at least one variable that will require participants to ask for outside help or advice (e.g., structural damage, loan object, etc.). The amount of time required will depend upon the complexity of the scenario and variables involved. Plan for 45–90 minutes.
- Print out the scenario, Assessment Team Flow Chart, and checklists (see below); make sure the institutional manual is available if appropriate. Print out damage labels and/or make new ones to fit your scenario.
- Prepare an identifying badge for each participant: curator, conservator, registrar, or art handler/support staff (i.e. preventive conservation aide, collection care specialist, etc.—the people who know where the ladders and supplies are kept).
- Print out signs and pictures that describe specific collection damage and hazards (see below) and distribute them in the collection exercise area. In addition to signs, long triangular slips of paper may be scattered to indicate broken glass, black paper squares to indicate soot or particulate contamination, and cotton balls to indicate mold.

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- Find a quiet room with space for the team plus facilitator.
- Make sure there is phone, radio, or walkie-talkie connection in both locations.

Carrying out the exercise:

1. Have participants sit down and then briefly describe what will take place during the exercise. Assign or have participants choose functions and a team leader. Note that the function they receive is NOT a job title, but a function—they are not expected to have the skills or knowledge they may associate with that function, but they should play the role and be an advocate for that function as a critical part of the response.
2. Have the participants read the scenario (give them only the primary scenario in the first paragraph—they must ask questions to learn additional details like availability of power or elevators) and tell them you have good news—they are the assessment team called to respond to this scenario. They will be responsible for assessment and coordination throughout the incident. The scenario determines the time of day, season, and other specifics.
3. Have the individual(s) representing each function describe what they see as their major function after reviewing the Assessment Team Flow Chart. If this is a large group of eight to 12, have each functional group meet first to define their function.
4. You, as the facilitator, will now leave the room and assume the role of site manager. You should remain available by the designated communication device. The team should now discuss how they will conduct the assessment and review the checklists to anticipate where they might have problems or need resources. They should check in with the site manager with this initial plan before they leave for the collection site.
5. The assessment team should report in to the site manager from the collection site after an initial overview assessment to report the extent of damage and identify any immediate questions they have or resources needed. They should also let the site manager know who may need to be contacted inside and outside the institution. They should then complete the assessment in a detailed enough manner to formulate a plan, and return to the meeting room. If the team seems to be off track or struggling, the facilitator may visit the collection site to redirect if remote communication is not adequate.
6. After returning to the meeting room, the team will formulate a recovery plan consulting the checklists provided, particularly the Assessment Team Checklist. They should also formulate a plan for how the recovery will be coordinated and what responsibilities

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each of them will have. The facilitator/site manager should continue to be available by remote communication.

7. After the team feels they have planned to the extent possible, bring the exercise to a close. The facilitator joins the team and spends 15 minutes jointly critiquing the plan the team devised.
8. After the plan critique, spend a few more minutes debriefing. Possible questions:
 - a. Were you surprised by anything including your personal response?
 - b. What did you learn about the role of the four major functional groups of the assessment team?
 - c. Did the team communicate with the site manager adequately to move their work and preparation for the recovery forward?
 - d. Was there anything else you should have done before starting to assess the situation? Before leaving the collection site to plan?
 - e. What did you learn about what needs to be in place in order to be prepared to assess a collection emergency?

APPENDIX 2

Scenario 1

Galleries—Museum Exhibit with Platforms, Wall Cases, and Vitrines

A severe early-evening thunder storm in midsummer spawns fierce winds that hit the east side of the galleries, blowing out windows on the second floor and taking out a corner of the roof over the East Gallery, which currently has an exhibit featuring textiles, furniture, a painting, prints, and objects. Due to structural damage, collection emergency staff is not allowed in until four days after the event. Most of the large building and storm debris has been cleared and there is a very temporary tarp over the hole in the roof. Temperatures and humidity have been moderate, but mold growth is probable. Power has been restored to the building, but the HVAC is not functioning and the repair schedule is uncertain. **Note:** Only this paragraph is given to participants.

Additional Area to Discover: Water has dripped through to the East Lounge on the first floor where exhibit-related supplies and a large rolled rug are stored. The rug is partially wet. Books on a cart strapped into cradles and ready for installation are partially wet. Tools in a nearby display have begun to rust.

Primary Object Issues:

2nd floor: Some exhibit cases are broken and some are intact. Objects in those that are broken exhibit water damage, corrosion, and incipient mold. Environmental conditions in intact cases are unknown.

1st floor: Dyes in the rolled rug are bleeding, stained and swollen books are still strapped in cradles, and iron tools are corroding.

Additional Issues:

Logistical Complication: A textile on exhibit is on loan, objects are in locked cases—who has keys?

Environmental: High humidity throughout building, especially east end of first and second floors; mold risk.

Health and Safety: Building and storm debris including glass shards, the carpeting in the exhibit area is wet and slippery, mold risk.

Outside Assistance: Loan object, need to stabilize environment.

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Scenario 2

Museum or Historic House—Period Rooms

In a severe evening storm, a tree on the west side of the building slams into the side of the building, knocking out the gutter, breaking a couple windows on the second floor, and impacting a third-story dormer in an area used for ceramic storage. Torrential rain continues for the next four hours, making safe travel impossible. Security guards attempt to put up tarps and deploy pigs to contain water. Power is out, and outside temperatures are moderate. The assessment team arrives as dawn breaks. The area has been cleared as safe to enter. Power is still out and may not be restored for 24–48 hours according to the most recent report. Temperatures in the 90s are expected. **Note:** Only this paragraph is given to participants.

Additional Areas to Discover: Water has dripped through to the first floor, staining the curtains, wetting the top of the painted chest between the windows, and raising the humidity. An adjacent room on the second floor has musical instruments sensitive to relative humidity.

Primary Object Issues:

3rd floor: Broken pottery in window, some dampness.

2nd floor: Wet floor with broken glass and storm debris. Wet objects of all kinds. Humidity-sensitive composite objects, especially musical instruments. Branches from the tree have punctured a painting, torn a bed covering, and broken one piece of the mantel garniture.

1st floor: Loan object—damage to paint. Humidity-sensitive painted chest.

Additional Issues:

Logistical: The painted chest on the first floor is a loan object; elevator cannot run until power is restored.

Environmental: High temperature and humidity.

Health and Safety: Glass shards from windows; wet slippery floors.

Outside Assistance: Loan object; need to stabilize environment.

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Scenario 3

Stacks in a Library

On a holiday weekend, a light switch on the second stack level adjacent to the rare book cage short-circuits, causing sparking and heat that eventually ignites a smoldering fire in some newly acquired, badly deteriorated periodicals with strawboard bindings on an adjacent cart. The fire spreads to the nearest shelf, producing smoke and heat that set off the sprinkler head in that area and send a signal to the local fire department. Much of the library's on-site staff is off site for the day, but a few respond just as the fire department charges into the building, unreeling hoses. The firemen pull books off adjacent shelves and douse them with water to prevent the fire from spreading, and break into the rare books cage to do the same with the shelving range closest to the fire. Staff is allowed into the stacks three hours after the fire is out. Electric power is available. **Note:** Only this paragraph is given to participants.

Additional Area to Discover: Water has dripped down to the first stack level in an area where a collection composed of manuscripts, photographs, and design drawings are housed—wet boxes, some soaked through. Water-damaged photos. A large, rolled, stained-glass window cartoon left on the counter is wet and stained.

Primary Object Issues:

2nd stack level: Wet, partially wet, damp, and sooty materials. Smoke/heat damage. Significant amount of coated paper in affected stack area. Affected rare book area has many parchment and leather-bound books.

1st stack level: Document boxes containing most of collection are unevenly damp/wet. Some have soaked through to contents. Stained-glass window drawing is very large, executed in poorly fixed charcoal, and rolled onto an acid-free tube with polyester film partial sleeve. A challenge will be to locate and secure an area where it can be examined and stabilized.

Additional Issues:

Logistical Complication: A valuable book on loan from a dealer is partially wet and stained. The stacks elevator can't be used until it is re-inspected, which could take several days.

Environmental: High humidity from water, but HVAC is functioning.

Health and Safety: Wet floor with standing water, soot, and combustion products.

Outside Assistance: Dealer owned book, freeze-drying, removal of standing water.

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ASSESSMENT TEAM FLOW CHART

Each team has four roles with specific functions during each phase of response. Each role **must** be respected and given space and time to operate successfully.

1. Initial assessment, required functions by role:
 - Registration—record event, record object moves necessary to stop immediate damage
 - Art handling—object moves and protection necessary to stop immediate damage
 - Conservation—situation assessment to determine incident extent and conservation resources needed
 - Curator/collection manager—situation assessment to determine incident extent and institutional resources needed
2. Communication: team leader or designee only
 - Call site manager and report:
 - Extent of incident
 - Urgency—status of problem (i.e. active, under control, inactive)
 - What has been done so far, what needs to be done immediately
 - Immediate resources needed—people, materials, actions
3. Plan the response in meeting chaired by team leader:
 - Registration—ID areas available for objects that need to be moved out of incident area and prep needed. Who should be called to help object moves/packing response?
 - Art Handling—ID resources necessary to make moves and access/egress routes
 - Conservation—ID conservation resources needed and object condition priorities. Who should be called to help conservation response?
 - Curator/Collection Manager—ID institutional resources needed (facilities, vehicles, lighting) and overall object priorities. Who needs to be notified?
4. Communication: team leader or designee only
 - Call site manager and report:
 - Type and number of objects involved
 - Priorities based on risk, logistics, resources available, and overall assessment
 - Recovery Plan outline with actions to be taken in chronological order
 - Detailed list of resources needed: people, supplies, equipment, outside assistance
 - Coordination Plan—who is in charge of what?
 - Communication/Reporting Plan
5. Begin collection recovery

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ASSESSMENT TEAM CHECKLIST

Before Entering Emergency Area:

- ☐ Review health and safety issues and take necessary precautions
- ☐ Is there safe access? Best path(s)?
- ☐ Review individual team duties
- ☐ Establish communication path(s) for team

Initial Assessment and Communication:

- ☐ Determine urgency of situation
- ☐ Move/protect objects in immediate danger if possible
- ☐ Determine extent of emergency
- ☐ Determine if emergency is major or minor
- ☐ Determine initial resources needed
- ☐ Team leader communicate to site manager

Assessment:

- ☐ Document overall area and objects in situ
- ☐ Assess degree of damage to objects
- ☐ Set object priorities—vulnerability, value, accessibility
- ☐ Identify potential handling/movement issues
- ☐ Assess potential resources available and obstacles such as no electricity or elevators
- ☐ Team Leader communicate assessment results and any resource requests to site manager

Plan:

- ☐ Protect in situ? Which objects? How? Who? Resources? Documentation?
- ☐ Move to safety in adjacent spaces? Which objects? Prep spaces? How? Who? Resources? Documentation?
- ☐ Move to safety in more remote spaces? Which objects? Prep spaces? How? Transport path? Who? Resources? Documentation?
- ☐ Move to conservation labs to begin recovery? Which objects? Prep spaces? How? Transport path? Who? Resources? Documentation?
- ☐ Move off-site for storage, freeze-drying, etc.? Which objects? Arrange with outside vendors? Transport path? Who? Resources? Documentation? Pack objects? How?
- ☐ Team leader communicate to site manager plan results and additional resource needs

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ASSESSMENT TEAM CHECKLIST

Coordination:

- ___ Who will coordinate each part of the recovery? Documentation? Supplies? Object movement? Object stabilization? Treatment?
- ___ How and when do assessment team members report to team leader? To site manager? What additional communication devices/paths are needed?
- ___ Who manages and briefs additional responders called by site manager?

APPENDIX 2

HEALTH & SAFETY CHECKLIST

Identify Hazards:

- ☐ Wet/slippery floors
- ☐ Mold
- ☐ Particulate matter/smoke residue in air and/or on objects
- ☐ Contaminated water
- ☐ Excessive heat
- ☐ Excessive cold
- ☐ Low light levels
- ☐ No elevator—work requires climbing multiple flights of stairs
- ☐ Difficult communications
- ☐ Unstable conditions

Remedies:

- ☐ Rubber soled shoes or boots
- ☐ Respirator for mold—N-95 or better
- ☐ Gloves
- ☐ Dust mask
- ☐ Tetanus/hepatitis A and B vaccinations
- ☐ Coveralls
- ☐ Hardhat
- ☐ Safety glasses or goggles
- ☐ Limited work schedule
- ☐ Lights
- ☐ Drinking water
- ☐ Health assessment
- ☐ Establish check-in and check-out procedure

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RESOURCE CHECKLIST

Operations

- ☐ Items from health and safety list
- ☐ Individual collection emergency kit items, especially gloves
- ☐ Lights
- ☐ Extension cords, adapters
- ☐ Documentation kits, cameras
- ☐ Communication items—radio, walkie-talkies

Collection Protection—ideally should be in collection emergency kits located in/adjacent to collection areas

- ☐ Tarps
- ☐ Buckets
- ☐ Absorbent materials—sponges, pigs, mats, rags
- ☐ Pole wall (telescoping poles used in construction to secure plastic sheeting)
- ☐ Blue tape

Environment

- ☐ Wet/dry vacuums
- ☐ Mops/wringers
- ☐ Fans
- ☐ Psychrometer/environmental logger
- ☐ De-humidifiers
- ☐ Space heater
- ☐ Humidifier

Object Transport

- ☐ Carts
- ☐ Baskets/bins
- ☐ Weights/rags/cushioning
- ☐ Floor pads
- ☐ Tables
- ☐ Safe space(s) for moved objects

Assistance

- ☐ Institution staff—who?
- ☐ Disaster recovery company (freeze drying, dehumidification, etc.)
- ☐ Outside conservators
- ☐ Other outside resources/vendors

LABELS

WET – SOAKED

WET – SOAKED

WET – SOAKED

WET – SOAKED

WET – SOAKED

PARTIALLY WET/STAINED

PARTIALLY WET/STAINED

PARTIALLY WET/STAINED

PARTIALLY WET/STAINED

PARTIALLY WET/STAINED

WET/GLASS/DEBRIS

WET/GLASS/DEBRIS

WET/GLASS/DEBRIS

LABELS

WET/GLASS /DEBRIS

WET/GLASS/DEBRIS

DAMP

DAMP

DAMP

DAMP

DAMP

DAMP

WET

WET

WET

WET

APPENDIX 2

LABELS

WET

WET

STUCK TOGETHER

STUCK TOGETHER

BROKEN

TORN

BROKEN

TORN

BROKEN

TORN

BROKEN

TORN

BROKEN

TORN

DAMAGED FINISH

DAMAGED FINISH

CORROSION

CORROSION

BLEEDING COLOR

BLEEDING COLOR

HIGH RELATIVE HUMIDITY

HIGH RELATIVE HUMIDITY

TEMPERATURE 80°F

TEMPERATURE 80°F

MOLD

LOAN OBJECT

MOLD

LOAN OBJECT

MOLD

APPENDIX 3

Collection Emergency Assessment and Response Training Session 3: Assessment and Recovery with Wet Objects

Exercise designed by staff at the Conservation Center for Art and Historic Artifacts (CCAHA), Philadelphia, PA, for use in their emergency preparedness and response training workshops

Compiled for distribution by Dr. Joelle D. J. Wickens, Conservator, Preventive Team Head, and Affiliated Assistant Professor for the Winterthur/University of Delaware Program in Art Conservation with input from Dyani Feige, Director of Preservation Services, CCAHA

Exercise Purpose and Goals:

This exercise, when used in full, will give participants an opportunity to imagine what happens when a variety of objects gets wet, see what happens when those objects actually get wet, and practice recovering those wet objects. In brief, it will build familiarity with wet object vulnerabilities. It will expose participants to salvage-specific challenges including recording object moves, teamwork, space and materials limitations, and decision making. It is geared toward those with little to no emergency response and wet object experience. The exercise is designed to be a low to medium stress method of introducing people to a high stress activity.

Essential Elements:

- A facilitator who has full knowledge of how the exercise should run and what the key learning opportunities are
- Sufficient and appropriate objects and supplies
- Someone familiar with wet object vulnerabilities
- This exercise should be preceded by the two other exercises provided within this document

Group Size:

This exercise can be adapted for any number of participants. The ideal number for the recovery portion is teams of five or six. Large groups should be split into smaller teams for this portion. Larger groups will require a significant amount of supplies, which may be prohibitive.

Materials Needed:

- A set of bins and objects for demonstration and teaching (see below)
- A bin, objects, and recovery supplies for each recovery group (see below)

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Exercise Description:

Either several hours or (ideally) the day before the wet recovery exercise, a set of demonstration objects is displayed prior to wetting. Participants are invited to examine the objects and draw conclusions about what will happen when they get wet. These objects and the as-yet-unseen ones that will be used in the recovery exercise are then wet and left overnight. The next morning, the previously viewed demonstration objects are used to support a review of wet object vulnerabilities. Recovery teams are then established and participants work to recover a bin of wet objects.

Facilitator Instructions:

Prior to the exercise:

- Gather all necessary materials
- Arrange materials in bins as described below

Several hours or ideally the day before the wet object recovery exercise:

- Have participants examine the demonstration objects prior to wetting. Provide copies of *Examination Guide for Use Before and After Wetting Materials* (see below) to guide their thinking.
- Have participants help pour water over the demonstration objects—observe how objects react and the rate at which water is absorbed.
- Pour water over the recovery exercise objects, but do this without the participants present. If time for exercise is limited, wet these objects in advance.
- Leave all objects to soak for several hours or overnight.

Wet object recovery exercise:

1. Have participants re-examine, without touching, the now-wet demonstration objects. Review the assumptions they made about object response when examining the objects before wetting. Which assumptions were right and which were not?
2. Using the wet demonstration objects and the handouts below, review wet object vulnerabilities and recovery methods.

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3. Split participants into recovery teams of five or six. Have them assign the following roles:
 - a. Leader
 - b. Recorder
 - c. Supply officer
 - d. Photographer
 - e. Object handler(s)
4. Make sure participants are aware of where recovery materials are located.
5. Discuss the need to record object locations and make notes on recovery priority.
6. Encourage teams to establish an action plan before recovering objects. What will come out of the bins first? Where will objects be taken? Have they set up an object receiving area? Do they have the supplies they need? Does everyone understand the division of duties? If you have previously trained this group with *Collection Emergency Assessment Training, Session 2: Assessment in the Collection*, draw on lessons learned from that experience.
7. Have teams recover objects from assigned bins. The exercise can run to completion or the facilitator can end it when (s)he feels enough time has been spent to enable key learning opportunities.
8. Gather back as a large group to share experiences. What worked? What was a challenge? What was their emotional response to the exercise? If this had been a real emergency, what would have been different? What would they do differently the next time around?
9. Have all participants help with cleanup.

APPENDIX 3

DEMONSTRATION OBJECTS SUPPLY LIST

Paper Materials Tray:

- ☐ Coated paper
- ☐ Matted artwork, perhaps with pressure-sensitive tape
- ☐ Inkjet printed or dyed papers that will run
- ☐ Intaglio print
- ☐ Iron-gall ink sample with a wafer seal
- ☐ Gouache or watercolor
- ☐ Folded map (to demonstrate unfolding in water)
- ☐ Manila folder containing handwritten and/or printed papers, possibly with hardware (e.g., staples, paperclips, etc.)

Photo and Audiovisual Tray:

- ☐ Black and white silver gelatin print
- ☐ Polaroid print
- ☐ Resin-coated print
- ☐ Framed photo
- ☐ Slides in polyester sleeve
- ☐ Negatives
- ☐ Microfiche
- ☐ Optical disc
- ☐ Cassette tape/video tape in plastic case

Objects and Textiles Tray:

- ☐ Woven textile
- ☐ Shattered silk
- ☐ Small rug/quilt (to demonstrate weight of wet textiles)
- ☐ A variety of metals (ferrous and non-ferrous)
- ☐ Ceramic pot
- ☐ Basket
- ☐ Painting
- ☐ Wooden box with a lid

Book Tray:

Tray should have enough books to line them up as if they were shelved. Leave an inch or so of space for expansion once wet and try to find a variety of books. If possible, include:

- ☐ Vellum-covered book (to demonstrate extreme reactivity to moisture)
- ☐ Case binding with Mylar dust jacket (to demonstrate leaving on, unless it is trapping dirt next to the book)

APPENDIX 3

RECOVERY EXERCISE SUPPLY LIST

- ☐ Plastic bucket for filling trays
- ☐ Waxed paper (for slinging or wrapping books)
- ☐ Paper towels/blank newsprint (for interleaving books and/or stuffing baskets and pots)
- ☐ Nitrile gloves (several sizes)
- ☐ Clothesline/string (for hanging objects to dry)
- ☐ Paperclips (for hanging objects)
- ☐ Clothespins (for hanging objects)
- ☐ Scissors
- ☐ Twill tape
- ☐ Garbage bags
- ☐ Mylar/cheesecloth/net (for slinging objects to remove from water)
- ☐ Spatula (for lifting papers from water)
- ☐ Sharpie
- ☐ Small polyethylene sheets and tape (to wrap objects)
- ☐ Nylon net (to pad out textiles)
- ☐ Stack of blotters (to cover tables)
- ☐ Stack of Hollytex (for spreading over blotter on tables)
- ☐ Clipboards, paper, and pencils for record keeping
- ☐ One approximately 3-foot-square plastic bin for each group with a variety of materials:

Paper

- ☐ coated paper
- ☐ poor-quality paper/newspaper
- ☐ pigmented laser print (will not run)
- ☐ inkjet print/dyed papers (will run)
- ☐ handmade or laid paper
- ☐ iron-gall ink sample
- ☐ maps with watercolors (may bleed)
- ☐ cardstock

Photo

- ☐ black and white silver gelatin print(s)
- ☐ color print(s) of various ages
- ☐ Polaroid print
- ☐ framed photo or artwork
- ☐ slides in polyester sleeve
- ☐ negatives (in sleeves, if possible)
- ☐ microfiche (in sleeves, if possible)

Audiovisual

- ☐ optical disc
- ☐ cassette tape in plastic case

Objects and Textiles

- ☐ woven textile
- ☐ metal button with pin
- ☐ ceramic pot (whole or fragment)
- ☐ basket
- ☐ silk ribbon
- ☐ painting
- ☐ leather scrap

APPENDIX 3

EXAMINATION GUIDE FOR USE BEFORE AND AFTER WETTING MATERIALS

Participants should examine the contents of the demonstration bins before wetting, using the following points to guide their thinking. The contents should be re-examined several hours after wetting so initial assumptions can be re-evaluated.

- Which objects have ink/paint/pigment that will bleed/run/wash away?
- Is anything likely to stick together?
- What objects are likely to fall apart?
- What objects will be unchanged by water?
- Are there objects with moving parts? Will they function after being wet?
- Is there an object that will stain its neighbor?

For the bin that is filled with books:

- Note that the books are not packed tightly
- Lift the tray before the water is added
- Are all the books made with the same kind of paper/covers?
- Will all the books respond to the water in the same way?
- Will all books wick water in the same way?
- Will they all expand in the same way?
- Once the water is added, note the water line on the pan. Do you think the books will soak up all the water?

APPENDIX 3

QUESTIONS TO GUIDE SALVAGE

Is the object weak and/or heavy when wet?

If so, use a support to lift it from the water and carry it during transport.

Does it have bleeding dyes, red rot, or rust?

If so, immediately segregate it and either freeze it (for organic objects) or dry it (for metals).

Is it a book with clay-coated pages?

If so, freeze it or interleave it with waxed paper or silicone-release paper and then air-dry it.

Does it have a complex or layered structure?

If so, do not freeze it (paintings, complex photographs, varnished maps, veneer).

Should it dry fast or slow?

Fast: Paper, books, textiles, photos, metals, ceramics

Slow: Basketry, wood, leather, parchment bindings

APPENDIX 3

SALVAGE RECOMMENDATIONS BY MATERIAL TYPE

General

- You generally have 48 hours before mold will begin to grow
- Rinse with clean water unless colorants are bleeding
- Cut open Mylar enclosures if they are wet inside and carefully peel the object away
- Try to separate from frames, but STOP if object is sticking
- Do not peel pressure-sensitive tape. Cut it if necessary or dry the artwork in its mat.
- Coated papers should be addressed within six hours and should be kept wet until frozen or air-dried
- Separate objects and lift from the water using Mylar supports
- Use a microspatula or Mylar to gently lift corners
- Attempt unfolding when the object is in the water

Air Drying

- Set out wet objects on screens or blotter covered with Hollytex
- Change out materials as they become wet
- Documents without bleeding colorants can be interleaved and stacked
- Objects can usually be flattened by a conservator at a later date

Freezing

- Not a good technique for varnished maps, thick gouache, etc.
- Interleave every 2 inches or so for records. Paper folders are okay to use for this.
- Prints should be in folders with interleaving as well
- Whole map chests have been frozen. Drain the excess water first.
- Large pallets of wet materials need to be blast-frozen; otherwise, the center can mold

APPENDIX 3

SALVAGE RECOMMENDATIONS BY MATERIAL TYPE

General

- Don't touch emulsions

Priorities

- Immediate
 - Get cased photos (e.g., tintypes, daguerreotypes) to a conservator
 - Hang or freeze cellulose nitrate photos
- Within 48 hours—address color and black and white prints
- Within 72 hours—address films and negatives

Air-drying is preferred because vacuum freezing can alter the photographic surface

- Place the emulsion side up with Hollytex-covered blotter underneath
- Separate photos from enclosures and frames. STOP if the photo is stuck to the glass and dry it with glass down.
- CD racks are a useful place to dry lantern slides and gelatin glass plates
- Remove slides, negatives, and microfiche from sleeves if possible and hang on a line with clothespins/paper clips
- Hang optical discs from a line or place printed-side down on Hollytex-covered blotter
- Remove cassette tapes and liners from cases and dry with cassette openings down

Freezing

- Photos can be frozen in small bags and then thawed in small batches for air-drying. If you choose to freeze in order to buy time, remember:
 - Re-wet the photo before freezing if it has started to dry
 - Gelatin responds quite well to freezing
 - Interleave every 1–2 inches before freezing
 - Freezing in existing plastic sleeves is okay if the water is clean and it is done within 72 hours
 - Do not freeze resin coated prints

APPENDIX 3

SALVAGE RECOMMENDATIONS BY MATERIAL TYPE

Wet Objects/Textiles/Paintings

Organics

- Textiles
 - Support with net, Hollytex, sheets, etc. when moving
 - Don't unfold textiles when they are saturated
 - Degraded textiles become more fragile when wet, particularly weighted silk
 - Air-dry objects by:
 - Blotting with cloths/sponges
 - Sandwiching between absorbent layers and swapping out the top layer as needed
 - Using fans or a no-heat hair dryer
 - Using net or polyester batting to pad out layers of wet costume
 - Isolating metal buckles, buttons, etc. with Mylar cutouts
 - If an object with dye bleeding can't be immediately addressed, consider freezing it
- Leather
 - Wet objects will be discolored and feel wet
 - Fragility will vary depending on tanning process and state of deterioration prior to wetting
 - Reshape while wet, padding out with lightweight materials that will promote air circulation
 - Don't wrap with plastic as this will likely promote mold growth
 - Air-dry with no heat
- Baskets
 - Likely to be discolored and heavy when wet
 - While wet, reshape and support from all angles
 - Pad out with unprinted newsprint
 - Keep lids on and dry slowly
- Wood
 - Wrap small, joined objects in newsprint and plastic so they will dry slowly
 - Raise furniture onto 2x4s to promote air circulation
 - Open drawers slightly

APPENDIX 3

SALVAGE RECOMMENDATIONS BY MATERIAL TYPE

Inorganics

- Metals
 - Separate iron as quickly as possible to reduce staining of other objects
 - Prioritize the recovery of iron and archaeological materials
 - Rinse with clean water if necessary
 - Air-dry; a hair dryer or a warm heater may be used to accelerate drying
- Ceramics/Glass
 - Rinse with clean water if necessary
 - If an object is broken, keep all pieces together and protect edges from further damage
 - Pat and blot dry, watching for instabilities
 - Fans or low-temperature hairdryers can be used to speed drying

Paintings

- Can be quite heavy when wet, particularly if large
- Wet canvases will usually be more fragile than dry canvases
- Canvas and wood components may expand and contract at different rates, which can put both components under considerable stress
- If the surface of the painting is unstable, dry it face up
- If the surface is stable, it can be placed face down so water can be blotted from the canvas
- Air-dry slowly

APPENDIX 3

SALVAGE RECOMMENDATIONS BY MATERIAL TYPE

Wet Books

General

- You generally have 48 hours before mold will begin to grow
- Rinse mud off with books shut
- If the book is already saturated, it can be dunked in clean water to rinse

Wet books can be divided into three subcategories: saturated, partially wet, and damp

- *Saturated*—these books should be prepared for freezing with the following steps:
 - Squeeze out the water. Mylar sleeves can be cut open.
 - Separate leather/vellum covered books so someone with experience can use slower drying/restraints
 - Gently shape the book. The shape that goes into the freezer will come out.
 - Wax-paper-sling every other book with the shiny side out. If there is red rot, wrap each book.
 - Spine down in plastic-lined box (or Coroplast). Gigantic books lay flat in box or baker's tray
- *Partially wet*—either freeze or air dry
 - Steps for interleaving:
 - Place newsprint/paper towel every 20 pages or so
 - Replace interleaving as necessary
 - Do NOT interleave if freezing
- *Damp*—air dry
 - Fan out on top of blotter
 - Alternate/turn upside down
 - Press when dry to retain shape/get to book conservator

Special Cases

- Coated papers (art books, journals):
 - May leave a clay residue on everything
 - Will stick together/block
 - Freeze within six hours of wetting in preparation for vacuum freeze-drying later
 - It is okay to re-wet
 - Can air-dry, but must interleave each page with a non-stick (wax paper, Hollytex)
- Parchment documents
 - Wrap in plastic to keep damp. Get it to a conservator within 48 hours.

FOXY UNDERPANTS: OR THE USE OF CHELATORS, ENZYMES, AND SURFACTANTS TO REMOVE FOXING STAINS FROM LINEN UNDERPANTS

LAURA MINA

ABSTRACT—This paper describes a successful treatment to reduce foxing stains on a pair of men's linen underpants ca. 1830 in the collection of the Costume Institute at The Metropolitan Museum of Art. The underpants are ankle length and have a wide corset-like waistband containing 12 baleen stays. Such undergarments are rare in museum collections, yet provide a reminder of the importance of fashionable bodies for men. Foxing stains can be disfiguring on any work of art, but the stains were considered particularly distracting on the underpants.

While foxing stains are a common problem in textile collections, most recent studies have focused on paper collections. Building on research by paper conservators and scientists, this treatment addressed the metals and microorganisms that cause foxing stains. Rather than use bleaching agents, the underpants were wet-cleaned in a series of baths with the chelator ethylenediaminetetraacetic acid (EDTA), a lysing enzyme, and the surfactant sodium lauryl sulfate. An agarose poultice with hydroxybenzyl ethylenediamine (HBED) was used to target an area with dark stains. In both visible and ultraviolet light, the stains showed considerable reduction after the treatment.

RESUMEN—En este trabajo se describe un tratamiento exitoso para reducir las manchas de foxing en un par de calzoncillos de lino para hombres ca. 1830 en la colección del Instituto del Traje en el Museo Metropolitano de Arte. Los calzoncillos llegan a los tobillos y tienen un amplio cinturón similar a un corsé que contiene 12 ballenas. Tales prendas interiores son raras en las colecciones de museos, pero son un recordatorio de la importancia de los cuerpos de moda para los hombres. Manchas de foxing pueden desfigurar cualquier obra de arte, pero las manchas se consideraron particularmente notables en los calzoncillos.

Mientras que las manchas de foxing son un problema común en colecciones de textiles, la mayoría de los estudios recientes se han centrado en colecciones de papel. Basándose en la investigación realizada por conservadores de papel y científicos, este tratamiento se dirigió a los metales y microorganismos que causan el foxing. En lugar de usar agentes blanqueadores, los calzoncillos se limpiaron en una serie de baños con el agente quelante ácido etilendiaminotetraacético (EDTA), una enzima de lisis, y el tensioactivo laurilsulfato sódico. Se utilizó un gel de agarosa con hidroxibencil etilendiamina (HBED) para tratar un área con manchas oscuras. Tanto en luz visible como en luz ultravioleta, las manchas mostraron una reducción considerable después del tratamiento.

1. INTRODUCTION

This paper describes a successful treatment to reduce foxing stains on a pair of men's linen underpants ca. 1830 in the collection of The Metropolitan Museum of Art's Costume Institute. Foxing stains can be disfiguring on any work of art, but the stains were considered particularly distracting on the underpants. The treatment was based on an investigation of published books and articles that included analytic research and case studies. While foxing stains are a common problem in textile collections, most recent conservation studies have focused on paper collections. In addition to details about the treatment, the article includes information about the cultural context and material construction of the underpants. A literature review examines many of the relevant publications. Finally, observations and paths for further research are discussed.

FOXY UNDERPANTS: OR THE USE OF CHELATORS, ENZYMES, AND SURFACTANTS TO REMOVE FOXING STAINS FROM LINEN UNDERPANTS

2. MATERIAL CONSTRUCTION AND CULTURAL CONTEXT

The underpants (1999.395.1) are made of linen (note 1) in a balanced plain-weave with approximately 60 threads per inch (fig. 1). They have a wide yoke waistband and tapered ankle-length legs. The waistband is made with a double layer of linen with 12 baleen ribs and closes at center front with four metal buttons and an open fly. Five narrow linen tapes pass through eyelets at center back and wrap crosswise around the body (fig. 2). The tapes terminate at two linen tabs that can fasten to multiple buttons on the front of the waistband, and thus modify the compression. The legs are cut in four pieces; the front pieces are set straight into the waist, while back pieces are cut with considerable fullness at the tops and are pleated at the waistband. At the ankles, there are short openings on the outseams that button closed. The underpants are entirely hand sewn with linen thread, and the long seams are flat felled.

Curators at the Los Angeles County Museum of Art (LACMA) requested the underpants for inclusion in their 2016 exhibition, *Reigning Men: Fashion in Menswear, 1715–2015*. Clarissa M. Esguerra, assistant curator of Costume and Textiles at LACMA, noted that the underpants are similar to a woman's corset from the same time period that is in the LACMA collection (M.63.54.7). In addition to similar construction, both the corset and the underpants contribute to an hourglass shape for the body, which was fashionable for both men and women during the 1830s.



Fig. 1. Linen underpants, ca. 1830 (MMA, Costume Institute Benefit Fund, 1999, 1999.395.1) with linen shirt, 1820s (MMA, Gift of Douglas Robbins, 1958, C.I.58.27.1), front view. Courtesy of MMA.



Fig. 2. Linen underpants with shirt, back view. Courtesy of MMA.

Many suits from the 1830s included cutaway coats that were waist-length in front, and worn with flat-front trousers with tapered legs—a style that placed emphasis on the abdominal area. Satirical cartoons provide evidence that male bodies that failed to conform to fashionable standards could be ruthlessly ridiculed.

3. FOXING RESEARCH

While the underpants are beautifully crafted and are a significant artifact of fashion history, the pervasive foxing stains compromised their appearance (fig. 3) and a treatment was needed to reduce the stains before exhibition. The development of a treatment proposal required extensive research to better understand the composition of foxing stains, as well as advantages, limitations, and risks of different treatment options.

The term “foxing” is difficult to define without resorting to descriptions of what it is not. The *Getty Art & Architecture Thesaurus* defines foxing simply as “pale, brownish, diffuse spots that appear on paper or other surfaces.”

The etymology is equally intriguing and unclear. Paper conservators have compared the rusty red color of some foxing stains to the color of foxes, and dated the term’s use to the mid-19th century (Lydenber and Archer 1931; Meynell 1979). The stain’s name may reference Reynard the Fox—an anthropomorphic trickster character appearing in medieval European tales. This connection is supported by definitions of “fox” in the *Collins Dictionary*, which include: to perplex or confound; to cause paper to become discolored with spots; to trick or deceive. Certainly, foxing has foxed conservators and scientists for many years.

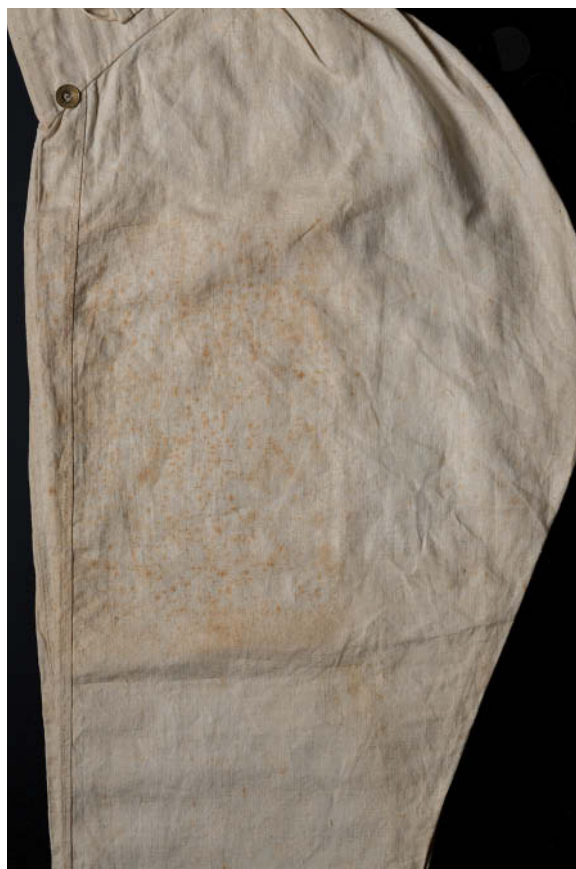


Fig. 3. Detail of underpants on back proper left leg, before treatment. Courtesy of author.

FOXY UNDERPANTS: OR THE USE OF CHELATORS, ENZYMES, AND SURFACTANTS TO REMOVE FOXING STAINS FROM LINEN UNDERPANTS

3.1. FOXING CAUSES AND CLASSIFICATIONS

Foxing is typically used as an umbrella term to include stains with a wide variety of colors, shapes, and sizes that can be further classified according to their visual characteristics and by analysis of their compositions.

The “Great Foxing Debate,” to borrow the title of a paper by Schaefer (1993), is focused on the causes of foxing stains. The two sides of this historical debate are biological microbial activity or chemical metal-induced degradation, with a third option proposing both systems working simultaneously or sequentially.

Foxing stains are most typically identified by examination under visible and UV lights. UV lights may reveal areas of fluorescence that do not appear stained in visible light. Rebrikova and Manturovskaya (2000) suggest that fungal foxing stains are most luminescent during their early stages. A few authors have found discrepancies in fluorescence and caution against reliance on this type of analysis (Florian 2000; Greve 2000; Zotti et al. 2011). Other analytic methods to distinguish between microbial and metal causes include binocular microscopy, SEM, FTIR, and energy dispersive XRF (EDX). However, these analyses are not always available or possible to make without destructive sampling.

One classification system for foxing stains is included in a chapter in *The Paper Conservation Catalog* (Derow and Owen). Published in 1992, this comprehensive source is still widely referenced by conservators. The chapter describes different types of foxing stains using four terms created by Cain and Miller (1982) based on shape, color, and UV fluorescence. The two most common types are bullseyes and snowflakes (fig. 4). Bullseyes are small and round; these stains have metal cores that do not fluoresce in UV light. Snowflakes are larger with irregular edges; these stains often show microbial activity and have white fluorescence in UV light.

Other conservators have suggested alternative classifications. Florian is the most cited expert on fungal deterioration and has published widely on the subject; her book *Fungal Facts: Solving Fungal Problems in Heritage Collections* (2002) provides extensive information. In a 2000 article, Florian listed nine types of stains, each described according to visual observation, stereoscopic microscopy, and light microscopy as well as SEM and EDX analyses. The two most common types in this system are irregularly shaped fungal fox spots

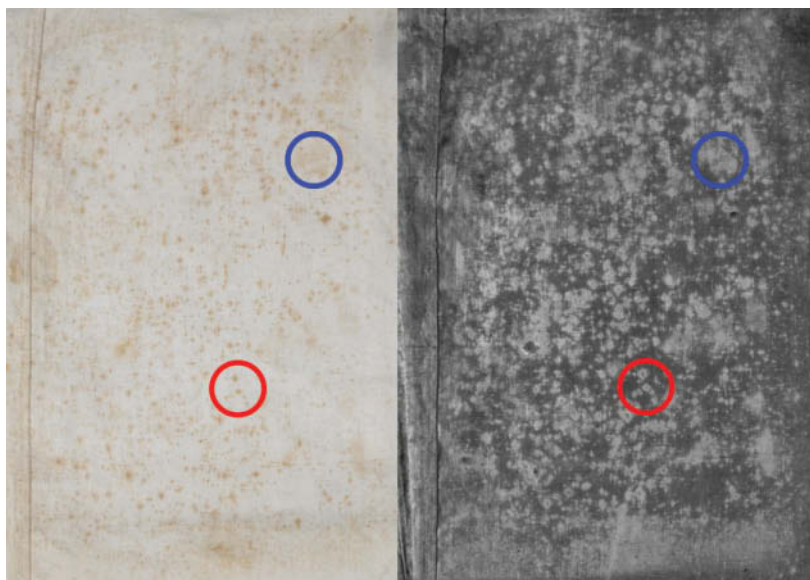


Fig. 4. Back view of underpants before treatment in visible light (left) and UV light (right). Bullseyes are marked with red circles and snowflakes with blue circles. Courtesy of MMA.

and corroded iron spots. These are roughly analogous to snowflakes and bullseyes, respectively. Some conservators use a modified version of Florian's system and reserve the term foxing exclusively for fungal stains.

Another excellent overview of foxing research is the article "Foxing on Paper: A Literature Review" (Choi 2007). Choi notes that none of the proposed classification systems for foxing stains have achieved widespread use, and that this contributes to a gap between scientific research and practical applications. Since research for this article included many different definitions and descriptions, the term "foxing" will be used with the broadest definition for simplicity's sake.

3.1.1. Metals

A few researchers have focused on metals in foxing stains. Cain and Miller (1982) used SEM and XRF to identify iron, copper-mercury, and copper-zinc. Both iron (II) and copper (I) are transition metal ions that can catalyze cellulose oxidation. Rebrikova and Manturovskaya (2000) describe this process and note that the formation of free radicals contributes to the degradation. Daniels and Meeks (1994) used EDX and SEM to analyze foxing stains; they found corroded brass (copper and zinc alloy), and noticed that dark spots contained copper (I) sulfide.

3.1.2. Microbes

A much larger group of researchers has analyzed foxing stains that contain fungal activity. Many conidial fungal strains and their amino acids have been identified in publications by Montegut et al. (1991), Aranyank (1995), Arai (2000), and Florian (2000). Typical strains include *Aspergillus* and *Penicillium* groups. Florian describes these as the "most widespread and destructive agents of decay on earth" (2002, 25). These authors mention that identification of specific genera or species can be challenging or impractical.

The dark colors of these foxing stains are related to pigments, including melanin, found in the fungal cell walls (Florian and Purinton 1995; Nieto-Fernandez et al. 2003). Fungal cell walls are distinctly different from those of plants. Fungal cell walls contain beta-glucan and chitin instead of cellulose. Chitin is also found in insect exoskeletons, so it is unsurprising that fungal stains are not water soluble.

Several researchers have documented the process of microbial damage on cellulosic fibers. Once small colonies of fungi form on a fiber surface, they begin feeding through their hyphae. These externalized stomachs can depolymerize fibers as they secrete enzymes that convert cellulose to glucose and soluble sugars (Montegut et al. 1991; Mandels and Reese 1999). Microbes can feed on surface micro-dust and damage textiles even before their hyphae target fibers. The feeding process produces organic and amino acids. As glucose reacts with these amino acids, brown spots are formed in the Maillard reaction (Florian 1993; Arai 2000). In addition, beta-glucan in fungal cell walls can brown as the fungi age and die (Florian 2000, 2002).

3.1.3. Multiple Causes

With the exception of a few authors including Arai (2000), Florian (2000), and Nunes et al. (2015), most studies suggest that foxing stains include metal and microbial components. While *Fungal Facts* rejects labeling metal-induced stains as foxing, it describes the process by which fungal cell walls seek trace elements and chelate with iron, copper, and zinc.

Recently, Sullivan et al. (2014) analyzed foxing stains with fungal and iron components. This study used a fluorescent staining protocol to confirm the presence of chitin, and XRF to confirm that iron levels within stains were higher than in unstained areas.

The foxing stains on the underpants were examined in visible and UV light (fig. 4). Based on areas with fluorescence, it appeared that most of the foxing was related to microbial activity. UV photographs revealed

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Table 1. pH and Conductivity Readings

Stain type (Three areas of each type were tested)	pH		Conductivity	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Dark stains	4.6–4.8	5.9–6.0	140–310 μS	65–135 μS
Light stains	4.7–5.2	5.8–5.9	120–230 μS	24–52 μS
No visible stain	5.7–6.0	5.7–5.8	50–180 μS	11–24 μS

many fluorescent areas that did not appear to have foxing stains in visible light, which might indicate less advanced microbial activity. The area on the back proper left with the darkest spots appeared to have metal components based on fluorescent patterns characteristic of bullseye stains.

The pH of areas with and without foxing stains was tested using small disks of 4% w/v agarose gel made with deionized water. The gels were left in contact with the linen for 30 minutes and then placed in a pH meter (note 2). The foxing stains were more acidic than the unstained areas, and the darkest foxing stains were the most acidic (see table 1).

3.2. FOXING TREATMENT OPTIONS

Interventive treatment options researched for this project include: surfactants, pH- and conductivity-calibrated solutions, bleaches, chelators, and enzymes.

The use of detergents is not typically effective in the reduction of foxing stains since they are not water soluble, but Montegut et al. (1991) recommend washing treatments to remove acidic oxidative byproducts. A study by Mandels and Reese (1999) found that anionic detergents significantly inhibited microbial activity.

Many paper publications, and all those for textiles, recommend bleach treatments to remove foxing stains. The generally preferred treatment for paper involves a sequenced process: the chelator EDTA targets metal components, followed by a reducing bleach such as sodium dithionite (Burgess 1991; Derow and Owen 1992). Burgess (1991) notes that without a chelator, incompletely removed iron material may re-oxidize, causing the stains to reappear.

In *The Textile Conservator's Manual* (1998, 72), Landi recommends “an oxidizing or reducing agent to remove [the stain] fully.” *Chemical Principles of Textile Conservation* (1998) by Tímár-Balázs and Eastop does not specifically address foxing stains, but does suggest bleaches and chelators for mold and rust stains, respectively. In the more recent *Changing Views of Textile Conservation* (2011, 386), an article by Ringgaard recommends the reducing bleach borohydride to remove “smaller brownish spots known as foxing.”

Solutions with calibrated pH and conductivity levels are increasingly utilized for stain reduction treatments. Keynan and Hughes (2013) successfully removed mold from a paper-covered sculpture using an aqueous solution adjusted to match the conductivity and pH of an area with mold stains.

Other studies have explored the potential for enzymes to treat foxing stains. Nieto-Fernandez et al. (2003) experimented with two different ligninases, but noted that the treatment produced some distortions on the test papers. Other conservators have also tested the potential of enzymes, but with limited success (Edmonds and Horton-James 1991; Florian 2000; van Dyke 2003).

A recent successful treatment to reduce foxing stains on paper is described in Sullivan et al. (2014). Sullivan tested the combination of the chelator HBED (N,N'-Di(2-hydroxybenzyl)ethylenediamine-N,N'-diacetic acid monohydrochloride) and a lysing enzyme (Glucanex) to reduce foxing stains. HBED is a strong chelator for iron. Glucanex is a proprietary lysing enzyme containing β -glucanase, cellulase, protease, and chitinase activities. Chitinases, glucanases, and peptidases are referred to as wall-associated enzymes because they target and break down fungal cell walls (Bowman and Free 2006).

Sullivan measured test areas with XRF and colorimetry as well as visible and UV photography. While the post-treatment visible-light photographs show considerable reduction in foxing stains, the other measurements are more impressive. The XRF data shows a significant decrease in iron, and the UV photography shows substantial reduction in fluorescence. These analyses indicate that the improved appearance was achieved by removing the causes of the foxing stains.

4. TREATMENT STEPS

All of this research was considered during the development of a treatment proposal for the underpants. While aesthetic improvement through stain reduction was a primary goal, the treatment proposal focused on methods that directly addressed the causes; bleaching was rejected in favor of chelators and enzymes. The system used by Sullivan was the most closely aligned with the analysis and goals for the underpants. This protocol was translated from a poultice spot treatment for paper to an immersion bath for a textile garment.

It was not feasible to conduct physical tests due to the lack of surrogate test material and the short time available for treatment. The decision to perform a treatment without physical tests was not undertaken lightly; however, the literature research suggested that the proposed treatment would have a high chance of success with minimal likelihood to cause damage.

4.1. TREATMENT PREPARATION

Since the foxing stains appeared in all areas of the underpants, a full-immersion bath was chosen rather than spot treatments. This required the removal of all buttons and stays. The placement of stitches was documented, and minimal stitches were clipped to remove the stays.

After removing the buttons and stays, the underpants were mechanically cleaned with a Nilfisk vacuum. Next, the underpants were sandwiched between two pieces of soft nylon net. Basting stitches around the perimeter of the underpants stabilized them between the net layers. This allowed conservators to lift, fold, and flip the underpants during wet-cleaning by holding the net.

The Costume Institute's wet laboratory has deionized water on tap, but no wash table. A container for the wash bath was made out of a corrugated plastic box with a small hole cut at one short end. The box was lined with polyethylene sheeting that was secured to the sides with binder clips. A slit in the polyethylene aligned with the hole in the box, and a stopper was made with a small piece of polyethylene and a glass weight. To fit in the wash box, the underpants were folded at the center with one leg was on top of the other (fig. 5). This allowed the fabric in the seat area to spread out with minimal folds. The box was placed on a table to make it level with the sink. With one short end of the box extending over the sink, it was possible to fill and drain the wash box using existing plumbing.

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Fig. 5. Underpants in wash box. Courtesy of Glenn Petersen.

4.2. WET-CLEANING TREATMENT STEPS

The underpants were given a series of baths, and a timeline helped keep everything on track during a treatment that lasted about 11 hours. The sequence of baths was designed to escalate from less to more aggressive solutions, and to make the most effective use of the costly enzyme and chelator components. The treatment steps are detailed in table 2.

Table 2. Treatment Steps

Treatment	Duration	Notes
Day 1		
Glucanex bath prep—in pot on stove, add enzyme to pH adjusted water and heat	45 minutes	• 25g in 5 L for 0.5% w/v bath • pH = 6.0
Soak bath—deionized water	45 minutes	• pH = 7.3 • Conductivity = 1 μS
Calibrated bath 1—pH and conductivity	30 minutes	• pH = 6.3 • Conductivity = 300 μS • Water adjusted with citric acid and sodium citrate
Wash bath 1—with sponging, then soak with HBED poultice	40 minutes sponging 1 hour poultice	• 0.5% w/v Orvus, 1% w/v EDTA, 0.5 g/L SCMC • Each side was sponged for ~7 min • HBED poultice applied to back proper left rectangle
Rinse 1—deionized water	1 hour	• Rinse with deionized water poured slowly around HBED poultice for first 30 minutes

Table 2. Treatment Steps (*Continued*)

Treatment	Duration	Notes
Calibrated bath 2—pH for enzyme	30 minutes	• pH = 6.0 • Water adjusted with citric acid and sodium citrate
Glucanex soak	3 hours	• Flip every 30 minutes • Enzyme solution and underpants in plastic sling clipped to short ends of basin, water bath with warm tap water running in basin to maintain warm temperature (about 30°C) for enzyme
Wash bath 2—with sponging, 2nd soak with HBED poultice	30 minutes sponging 1 hour poultice	• Each side was sponged for ~7 minutes
Rinse bath 2—DI water	1 hour	• Rinse with DI water poured slowly around HBED poultice for first 30 minutes
Press with towels	15 minutes	
Unstitch net sandwich and pad underpants with dry net	15 minutes	
Dry with heat guns on low	1 hour	• Left to dry overnight with fans providing gentle air flow
Day 2		
Glucanex soak	2 hours	• Flip every 30 minutes • Enzyme solution and underpants in plastic sling clipped to short ends of basin, water bath with warm tap water running in basin to maintain warm temperature (about 30°C) for enzyme
Wash bath—with sponging, soak with HBED poultice	30 minutes sponging 1 hour poultice	• Each side was sponged for ~7 minutes
Rinse—deionized water	1 hour	• Rinse with deionized water poured slowly around HBED poultice for first 30 minutes
Press with towels	15 minutes	
Unstitch net sandwich and pad underpants with dry net	15 minutes	
Dry with heat guns on low	1 hour	• Left to dry overnight with fans providing gentle air flow

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After a soak bath in deionized water, the underpants were soaked in deionized water calibrated to a pH and conductivity close to that of the darkest foxing stains. This was followed with a wash bath using the anionic surfactant Orvus WA Paste (sodium lauryl sulfate), sodium carboxymethyl cellulose (SCMC) as a suspension aid, and EDTA. During the first part of the bath, each of the four sides of the underpants was repeatedly pressed with natural sea sponges (fig. 6). The last rotation left the proper left back leg face up. A poultice of 0.5% w/v HBED in 2% w/v agarose was placed on the area with the darkest foxing stains and left for 30 minutes. The poultice was partially submerged in the shallow bath.

Due to time constraints for the long treatment, the rinse time overlapped with the poultice time; non-poulticed areas were rinsed first while the poultice was still in place. After the poultice was removed, the entire garment was rinsed with deionized water. Next, a second calibrated bath brought the pH to 6 in preparation for the lysing enzyme Glucanex (note 3). The underpants were then lifted from the wash box, and placed on a polyethylene sling that was somewhat tautly stretched over the wash box and secured with binder clips. The wash box was filled with warm running water to create a bain marie at 25–27°C (77–80.6°F) and maintain the temperature needed for enzyme activity (fig. 7). The Glucanex solution was added to the sling with the underpants. A space heater in the wet laboratory helped to maintain a warm temperature.

After two hours soaking in the enzyme solution, the underpants were removed from the bain marie and returned to the wash box. A second wash procedure was conducted, repeating the same wash solution and poultice steps. Finally, the underpants were thoroughly rinsed with deionized water.

To dry the underpants, they were first blotted between cotton towels. The net sandwich was removed, and nylon net padding was inserted into the legs and waist area. The underpants were dried using three hairdryers on cool settings, and left overnight with two fans positioned to provide gentle airflow.

The underpants were visually examined the next day, and the foxing stains were much reduced. The stains were still visible however, and additional treatment was desired. Two additional solutions were tested on some of the darkest foxing stains. These solutions were chosen based on recommendations from other conservators and immediate availability of materials. The first test of sodium borohydride (0.1% w/v) and EDTA (2% w/v)



Fig. 6. Wet-cleaning the underpants.
Courtesy of Glenn Petersen.

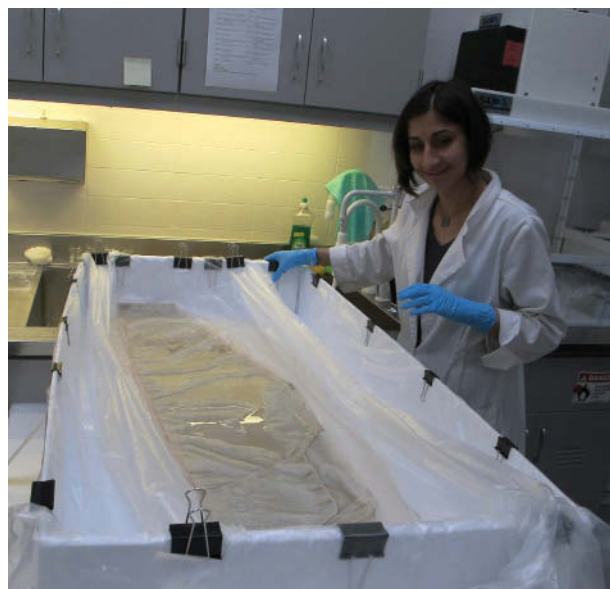


Fig. 7. The underpants and enzyme solution warmed in the bain marie. Courtesy of Glenn Petersen.



Fig. 8. Front view of underpants in visible light before treatment (left) and after treatment (right). Courtesy of MMA.



Fig. 9. Back view of underpants in visible light before treatment (left) and after treatment (right). Courtesy of MMA.

had minimal effect. The second test utilized citric acid (1% v/v); this had less effect on the stain than on the area adjacent to it. Each solution was brushed on a small stain and left for one hour. After each test, the treated area was rinsed with deionized water on a suction platen. Both solutions were rejected for this treatment.

Since contact time is a significant factor for treatments with chelators and enzymes, it was decided to re-treat the underpants with an abbreviated repetition of the first day's treatment. They were again stitched between pieces of nylon net. This treatment started with the enzyme bath, followed by another wash bath with chelator poultice. Finally, the underpants were rinsed and dried. The repetition of wash baths did provide a noticeable but small difference.

5. DISCUSSION

The use of chelators and enzymes to reduce foxing stains on the linen underpants proved very successful. The general appearance of the underpants was greatly improved (figs. 8, 9), UV light showed dramatically decreased fungal presence (figs. 10–12), and the pH of areas with foxing was less acidic (table 1).



Fig. 10. Front view of underpants in UV light before treatment (left) and after treatment (right). Courtesy of MMA.



Fig. 11. Back view of underpants in UV light before treatment (left) and after treatment (right). Courtesy of MMA.

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Fig. 12. Detail of underpants on back proper left leg in UV light before treatment (left) and after treatment (right).
Courtesy of MMA.

Two circumstances specific to this treatment deserve special mention. The HBED poultice in agarose failed to form a rigid gel, but maintained a thick, pudding-like texture as it cooled. The gel appeared to be compromised by heating the HBED and agarose together in solution. This contradicted the experiences of multiple conservators making smaller batches of poultices with the same materials. While the texture of the poultice was acceptable for use in combination with an immersion bath, it would have made removal problematic in a spot treatment. In addition, the underpants came into the collection highly starched. The treatment assumed that the foxing stains occurred after the underpants were starched, and thus the starch was not a cover layer over the stains; however, the presence of starch undoubtedly impacted the treatment. A significant amount of starch was removed during treatment, but some remains on the underpants.

6. CONCLUSIONS

The success of this treatment would not have been possible without access to the many excellent research articles and case studies published by conservators and scientists. Just as this paper built on the work of others, it is hoped that this process will continue and future papers will share ongoing research and treatments.

Many additional research paths could inform future treatments. A better understanding is needed regarding the impact of pH and conductivity calibrated solutions on textiles. Another avenue for study is an analytic comparison of chelators, enzymes, and bleaches on textiles with foxing stains. While chelators and enzymes successfully reduced the foxing stains by targeting their causes, a bleach treatment might further diminish the stains. Perhaps the most effective treatment will include a sequence of all three.

NOTES

1. Fiber identification with visible and polarized light microscopy.
2. Conductivity and pH tests utilized small plugs of 4% w/v agarose made with deionized water. The gels were in contact with the textile for 20–30 minutes. Measurements were taken with Horiba Laquatwin B-771 compact conductivity meter and B-71X compact pH meter.

3. Glucanex has maximum activity at 45°C and pH 4.5. Its active ranges are 25–60°C and pH 3.5–7.5 (Prieto et al. 2011; Sigma Aldrich 2014).

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SOURCES OF MATERIALS

Agarose, molecular biology grade

Benchmark Scientific
PO Box 709
Edison, NJ 08818
Tel: (908) 769-5555
www.benchmarkscientific.com

Citric acid

Pro Chemical & Dye
126 Shove St.
Fall River, MA 02724
Tel: (800) 228-9393
<https://prochemicalanddye.net/>

EDTA

Alfa Aesar
26 Parkridge Rd.
Ward Hill, MA 01835
Tel: (800) 343-0660
Fax: (800) 322-4757
www.alfa.com

Glucanex

Sodium citrate
Sigma-Aldrich Corp.
St. Louis, MO
Tel: (314) 771-5765
Fax: (314) 771-5757
www.sigmaaldrich.com

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HBED

Santa Cruz Biotechnology
10410 Finnel St
Dallas, TX 75220
Tel: (800) 457-3801
Fax: (214) 358-6070
www.scbt.com

Orvus WA Paste

Sodium borohydride
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
Tel: (800) 482-6299
Fax: (800) 605-7503
www.conservationsupportsystems.com

Sodium carboxymethyl cellulose

Talas
330 Morgan Ave.
Brooklyn, NY 11211
Tel: (212) 219-0770
www.talasonline.com

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GELLING IN THEORY AND PRACTICE: AN EXAMINATION OF AGAROSE GELS IN TEXTILE CONSERVATION

EMMA SCHMITT AND SARAH FOSKETT

ABSTRACT—Recent developments in poultice treatments have led to the introduction of agarose, a gelling agent derived from seaweed, into textile conservation and innovations in its application. Translating information on the use of agarose from published literature into actual practice has proved challenging, as predicting how these gels will work on different materials is complex.

This paper presents dissertation research carried out at the University of Glasgow to understand how the chemical and physical properties of agarose can be used to inform successful conservation treatments. Properties are assessed alongside results of tests utilizing these gels on textile substrates to better understand how the theoretical information presented in food and biological science literature informs and affects the use of these materials.

Testing examined three fibers (cotton, wool, and silk), three concentrations of agarose, and two different gel depths. The results showed that the success of a treatment is dependent on all three variables.

RESUMEN—Recientes desarrollos en los tratamientos con cataplasmas han llevado a la introducción de agarosa, un agente gelificante derivado de las algas marinas, en la conservación de textiles e innovaciones en su aplicación. La traducción de la información sobre el uso de agarosa en la literatura publicada a la práctica actual ha resultado un reto, ya que predecir cómo estos geles funcionarán en diferentes materiales es complejo.

Este artículo presenta una investigación de tesis realizada en la Universidad de Glasgow para entender cómo las propiedades químicas y físicas de la agarosa pueden ser usadas para informar los tratamientos de conservación exitosos. Las propiedades se evalúan junto con los resultados de pruebas que utilizan estos geles en sustratos textiles para comprender mejor cómo la información teórica presentada en la literatura de alimentos y ciencias biológicas informa y afecta el uso de estos materiales.

Las pruebas examinaron tres fibras (algodón, lana y seda), tres concentraciones de agarosa y dos profundidades de gel. Los resultados mostraron que el éxito de un tratamiento depende de las tres variables.

1. INTRODUCTION

Within the field of conservation, a poultice is an absorbent material that can be used to deliver water, a cleaning solution, or solvent to a substrate, usually with the aim of removing soiling or staining (Stulik et al. 2004; Poultice 2014). In textile conservation, poultice treatments are often utilized for the localized introduction of an aqueous solution or solvent when immersion cleaning is inadvisable. Most poultices work using the properties of diffusion and capillary action. When the wet poultice material is applied to a dry substrate, moisture moves into the substrate in an effort to balance the system. As the poultice begins to dry, the capillary action results in drawing moisture and any other soluble substances such as soiling from the substrate and into the poultice in order to retain equilibrium in the system (Lemiski 1998). Working with poultices requires knowledge and experience, as achieving a balance between diffusion and capillary action demands an understanding of the properties of the substrate, the poultice material, and the solvent. Poultices can be difficult to control and their use risks the formation of tidelines and migration of soiling.

The introduction of agarose, a gelling agent derived from seaweed, to the field of conservation offered a rigid gel poultice material that could theoretically offer greater control over the introduction of moisture into

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a substrate and leave no residue (Warda et al. 2007). The speed at which it was adopted in a range of specialties limited the amount of research done to understand how this material would work when combined with different media. This paper examines the chemical properties of agarose and presents a study of its use with three different textile substrates undertaken at the University of Glasgow.

2. AGAR VS. AGAROSE

The difference between agar and agarose gels must be understood before a discussion of their respective uses can commence.

Agar is a hydrocolloid gelling agent extracted from seaweed (Armisen 1997). A hydrocolloid is a polysaccharide or protein most commonly used as a gelling agent for aqueous solutions (Armisen et al. 2009). Agar is the oldest known seaweed-based gel, coming into use in Japan around 1658 (Armisen 1997). It has found use in the biological sciences, mainly as a growth medium for plants and bacteria. Agar-producing seaweeds belong to the class Rhodophyceae and are termed “agarophyte seaweeds” (Armisen 1997). Agar refers to the polysaccharides produced by these seaweeds. Other seaweed gelling agents, such as alginates and carrageenan, differ according to the type of seaweed from which they originate and vary in their polysaccharides (Armisen 1997).

Agarose is the main gelling component of agar and is purified for scientific use. In conservation applications, agarose gels are unusual for their ability to be used with a range of different additives, including chelators, enzymes, water-miscible solvents, and, with some limitations, bleaches. The broad compatibility of agarose can be attributed to its structure and its neutral charge. Agar is not purified to the same extent, and thus retains other components, including charged side groups such as sulfates.

2.1. STRUCTURE AND COMPONENTS

The structure of agar was identified by Araki in 1956. In the same article, he described agar as containing two polysaccharides, agarose and agarpectin, and outlined the structure of agarose. The polysaccharides are mainly composed of galactose, a monosaccharide, while a small percentage of the structure is made of sulfate esters (Armisen et al. 2009). Agarpectin molecules are similar in form to agarose but with greater sulfate content and lower molecular mass (Armisen 1997).

Agarose is a linear polymer of agarobiose units. Agarobiose is the term used for the monomer made of β -(1,4)-(3,6)-anhydro-L-galactose and α -(1-3)-D-galactose rings (fig. 1) (Armisen 1997). Variations within these singular units can occur depending on the species of seaweed and the season in which it is harvested (Armisen 1997).

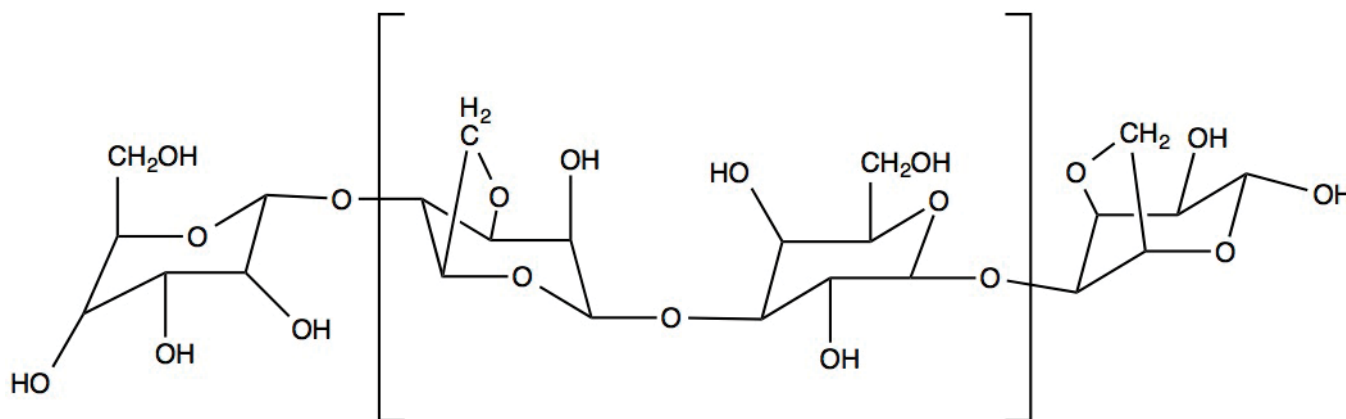


Fig. 1. The agarobiose monomer, β -(1,4)-(3,6)-anhydro-L-galactose and α -(1-3)-D-galactose.

Traditionally, the gels were extracted by freezing seaweed and then allowing it to thaw and dry. This produced flake or powdered agar (Armisen 1997). The process has since been commercialized, though the principles remain the same.

Rheology is the study of the flow of matter, and is important to understand in this context as it can be used to describe how the gel structure transforms as it changes phases from liquid to semisolid (fig. 2) (Labropoulos et al. 2002). Agarose gels transition from a dry powder to a liquid gel in the presence of water and heat. In its liquid state, agarose is a random coil; when it cools, the coil forms a double helix through the establishment of hydrogen bonds (fig. 2) (Labropoulos et al. 2002, 405). These double helixes crosslink and form a grid-like structure, thus creating the rigid gel (Arnott et al. 1974). This structure gives strength to the gels and forms the pores that allow for capillary action and diffusion to take place. This structure is crucial for the use of agarose gel in conservation, as it allows the gel to act as a poultice (Van Dyke 2004, 102).

2.2. AGAROSE GEL PROPERTIES AND PRODUCT CHOICE

A literature review has been used to identify some of the different types of agarose that have been used in conservation treatments and experiments. Table 1 provides a list of products that differ in price, properties, and sources. As these factors can affect treatment, an understanding of how and why agarose gels work is essential to ensure that the right product is selected for a given treatment, and obtained for an acceptable price.

The chemical companies surveyed for this paper listed up to seven properties associated with agarose gels. Three of these properties—grade, gelling temperature or transition temperature, and electroendosmosis—are considered below, as they may affect conservation treatments. In industry, agar gels are used differently, and as they are less pure, are not presented to the buyer with all of the same properties.

2.2.1. Grade

The trend seen in most conservation articles indicates a preference for molecular biology grade agarose (Campani et al. 1997; Warda et al. 2007; Pouliot et al. 2013). Agarose is used in the biological sciences for a range of different purposes including gel electrophoresis, a technique used to separate macromolecules, such as the nucleic acids that make up DNA, by size and electrical charge. As a result, molecular biology grade materials are purified to meet a specific standard, which is provided in the product literature. Purification involves the removal of agaropectin and other impurities that may restrict gelling capability or movement through the gel structure.

Agar, on the other hand, is usually marketed for microbiology as a growth medium for bacteria and does not require the same degree of purity.

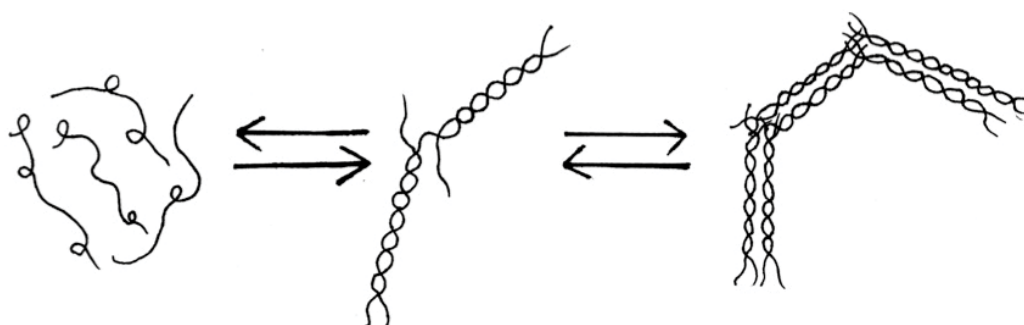


Fig. 2. The gelling phases of agarose from left to right: agarose in its liquid phase, the double helix forming and crosslinking as the gel cools, the crosslinked helices forming the rigid gel.

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Table 1. Properties of Agar and Agarose used in Conservation

Grade	Gelling Temp	Melting Temp	EEO	Use	Cost* *As of 2014	Source
IBI Molecular Biology Grade	36°C	88°C	0.005– 0.13	pH, Conductivity, Cleaning (Wolbers, pers. comm.)	\$111.00/100g	Universal Medical
IBI Molecular Biology Grade, Low Melt Point	24–28°C	65.5°C	0.12	Enzymes (Wolbers, pers. comm.)	\$295.00/100g	Universal Medical
Agarose LE Molecular Biology Grade	36°C	88°C	0.13	Cleaning (Shaeffer and Gardiner 2013)	\$104.00/100g	Benchmark Scientific
A9539 Molecular Biology Grade	36°C	N/A	0.09–0.13	Research, Testing (Schmitt 2014)	£151.00/100g	Sigma Aldrich
Fluka Agarose 05068	34–37°C	N/A	0.23–0.27	Testing, Cleaning (Campani et al. 2007)	Discontinued	Sigma Aldrich
Seakem LE Agarose	34.5– 37.5°C	90°C	N/A	Aging, Testing (Warda et al. 2007)	\$137.00/100g	Cambrex Bio Science
Fluka Agar 05040	35°C	70°C	N/A	Testing, Cleaning (Campani et al. 2007)	\$43.90/100g	Sigma Aldrich
VII-A A0701 Low Melt Point	26°C	65.5°C	0.12	Wolbers’ Workshop for Tex- tiles, Berlin, 2013	£727.00/100g	Sigma Aldrich
Fluka Agarose A4679	34–38°C	N/A	.09–0.13	Replacement for Fluka 05068 as recommended by Sigma Aldrich	£253.50	Sigma Aldrich

2.2.2. Gelling and Melting Temperature

An important property to consider for certain types of treatments is gel hysteresis, or the difference between the melting and gelling temperatures (Armisen 1997). In general, agarose melts above 80°C and gels at around 35°C (Armisen 1997). For most uses, including general cleaning treatments and the measurement of pH and conductivity, the heat needed to melt the agarose and the point at which the liquid begins to thicken are irrelevant, so any product can be selected.

Heat sensitive additives however, especially enzymes, may benefit from the use of a modified, low-melting-point gel, as their lower melting temperature will not denature the enzyme proteins as they are

added to the liquid gel solution. Low-melt gels can be used in the same conditions as a standard grade agarose. Despite the versatility of low-melt agarose, the price is usually more than double that of the standard agarose (table 1), and for this reason it may be more expedient to instead use the standard gel and add the enzyme as it cools.

2.2.3. Electroendosmosis (EEO)

Electroendosmosis (EEO) is the movement of liquid under the influence of an electric current (Agarose Matrix 2011). When powdered agarose is hydrated to form a gel, soluble counter cations will dissociate from charged side chains such as sulfates that have not been removed during purification. In the context of gel electrophoresis, EEO occurs when the applied electrical current causes these cations to move through the gel in the opposite direction of the molecules being separated, which can skew results through internal convection (Sigma Aldrich 2014). Because of this, low EEO gels are needed for electrophoresis. For conservation, this property has less effect, as there is no electric current being applied.

3. GLASGOW RESEARCH

The agarose gel study undertaken at the University of Glasgow (Schmitt 2014) aimed to identify ideal working standards on common textile fibers through the manipulation of the basic working properties. It examined three main questions:

- What effect does the type of textile fiber have on the rates of diffusion and capillary action of agarose gel poultices at given concentrations?
- How does the concentration of the agarose gel poultice affect/influence its working properties?
- Does the depth of the agarose gel affect its effectiveness as a poultice?

It was decided to test agarose rather than agar, as it had been used in the majority of published conservation treatments consulted (Van Dyke 2004; Stockman 2007; Warda et al. 2007; Ellis 2009; Sahmel et al. 2012; Pouliot et al. 2013; Shaeffer and Gardiner 2013). The agarose product chosen was one that is available worldwide through Sigma Aldrich at a median price point (table 1). Agar and preparation methods using solutions other than water were not included in this study in order to limit the number of variables tested.

Three plain-weave fabrics of similar thread count were chosen for testing: cotton lawn, silk habotai, and wool delaine. Fabrics were scoured and cut into equal-sized squares. These textiles were stained using Parker Quink, a water-soluble fountain pen ink, using a stencil to maintain consistent size and shape (fig. 3). Based on the physical properties of agarose discussed above and trends in existing literature (table 2), three concentrations of agarose gel—1% w/v, 2.5% w/v, and 4% w/v—were chosen for testing. Two depths of gel were also tested. 0.5 cm was chosen based on the most commonly used gel depth described in conservation literature and 0.3 cm based on the observation of the free-form gel depth that occurs when agarose is poured on a flat surface (Van Dyke 2004; Sahmel et al. 2012).

Agarose was weighed out according to the concentration being made. Deionized water was then added and the solution was placed on a hot plate and heated to 85°C, or until the solution was clear and no powder was visible in the beaker. The liquid gel was then poured into macaroon molds to form the individual gel disks. After about half an hour, the gels had set and cooled, and could be removed from the molds.

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Fig. 3. Application of ink onto fabric using a brush and stencil.

Table 2. Summary of Trends in Conservation Treatments Utilizing Agarose or Agar

Author	Medium	Gel Concentration	Gel Depth	Time Applied	Treatment
Van Dyke 2004	Paper	1.2% Agarose	0.5–0.8 cm	N/A	Enzymes
Stockman 2007	Paper	1.2% Agarose	N/A	N/A	Enzymes
Warda et al. 2007	Paper	1% Agarose	N/A	1–4 min.	Adhesive removal (no enzymes)
Pouliot et al. 2013	Ceramics	2–4.5% Agarose	N/A	N/A	Cleaning
Campani et al. 2007	Ceramics	1.5% Agarose 2% Agar	1 cm	90–160 min.	Residue investigation
Sahmel et al. 2012	Textiles (Wool)	1% Agarose (4% for Tests)	~0.5 cm	15 min. to 60 min	Cleaning
Shaeffer/Gardiner 2013	Textiles (Linen)	1% Agarose (4% for Tests)	N/A	1 hr.	Cleaning
Ellis 2009	Textiles (Cotton)	1% Agarose	N/A	N/A	Enzymes
Younger/Duffus 2014	Textiles (Cotton)	2.25% with Agarose 3.5% with Agar	N/A	2 hr.	Cleaning
Gulotta et al. 2014	Stone	3% Agar	Painted onto surface	30 min.	Cleaning

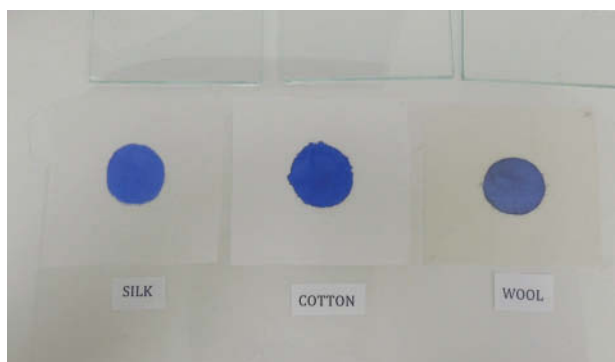


Fig. 4. Examples of fabric prior to gel application. Fabrics from left to right: silk, cotton, wool.

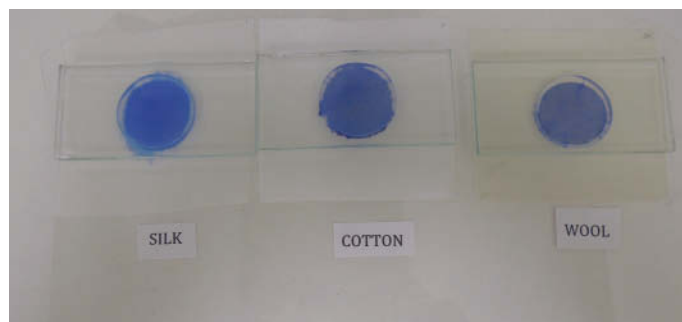


Fig. 5. Examples of gels applied to fabric samples. Fabrics from left to right: silk, cotton, wool.

Gels were placed on the textiles on top of the ink stains and lightly pressed into place; glass weights were also placed on top to increase surface contact (figs. 4-6). This system was left in place for an hour. The gels were then examined and photographed, and the following information was recorded:

- the degree of contact as evidenced by the fabric imprint on the gel,
- how much and how evenly the stain was absorbed into the gel matrix, and
- the increase in the diameter of the stain.

The procedure was repeated four times for each fiber type, gel concentration, and gel depth to achieve statistically significant results.

3.1. DEFINITION OF TERMS

Wicking is the lateral movement of water or solvent through a substrate, that may carry with it any solubilized substances. Wicking is dependent on the amount of liquid released, the properties of the substrate through which it is moving, and the environmental conditions in which it is happening. Tidelines represent the point at which the solvent or water evaporates, leaving residual soluble matter in concentrated form. For this project, the extent and nature of the tidelines and ring marks were used as a guide to understand the amount of water released. The term “ring mark” or “ringing” is used here to describe the overall stain caused by ink residue being

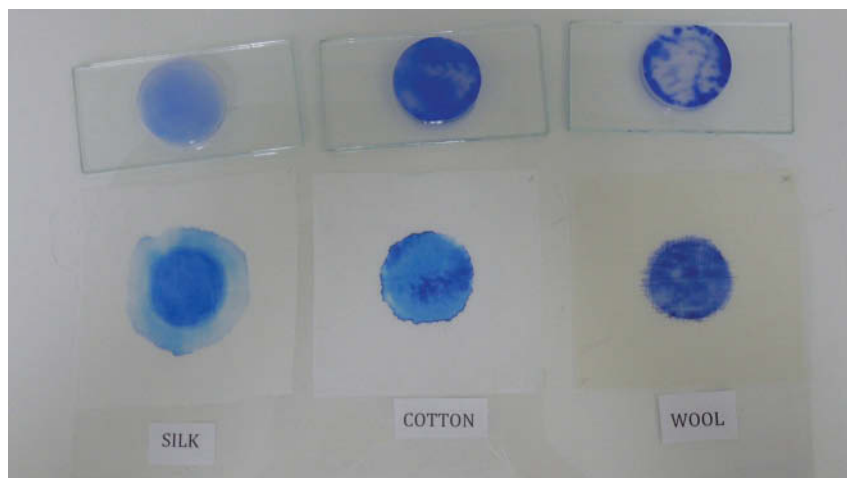


Fig. 6. Examples of fabric and gels after tests. Fabrics from left to right: silk, cotton, wool.

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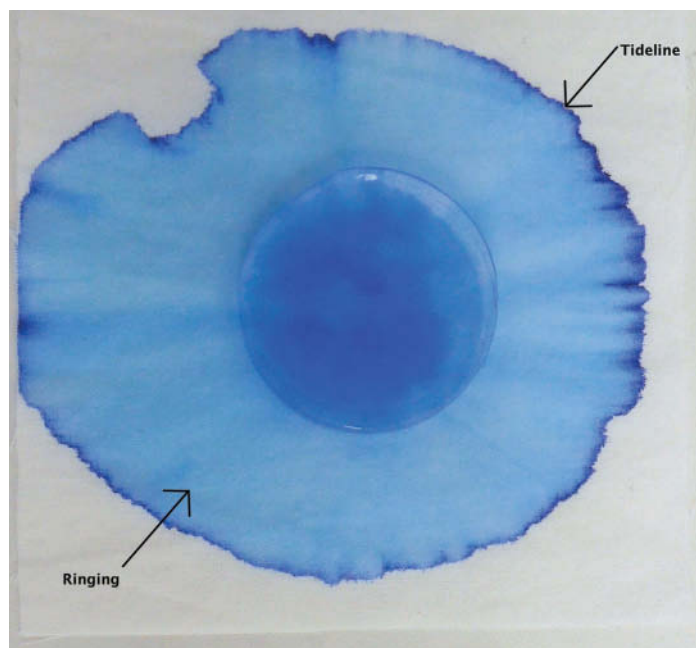


Fig. 7. Example of ringing and tidelines.

drawn along the fibers from the outward movement of water from the gel into the substrate (fig. 7). “Tideline” is used to describe the concentrated line of staining along the outer edge of the ring mark (fig. 7).

3.2. RESULTS

3.2.1. Silk

Compared to the other fiber types, silk showed the most water movement through the fabric at all concentrations. Wicking carried the ink outside the original dimensions of the stain in all tests (figs. 8-10). This movement resulted in ringing and a faint tideline, as the moisture from the gel wetted out much of the textile, emphasizing the challenges of controlling wicking in silk fabrics. Decreases in gel depth and increases in concentration reduced this movement; however, the wicking was still comparatively extensive when gels were applied to silk versus when they were applied to cotton and wool.

3.2.2. Cotton

Cotton exhibited less wicking of the ink through the textile than silk (figs. 8-10). Tidelines were prevalent in all the tests. Lateral spread could be controlled by changing concentration and depth and ensuring good contact between the gel and the textile. For example, a balance between the rates of diffusion and capillary action was achieved at a concentration of 2.5% when there was enough surface contact, as evident by the limited wicking into the textile (fig. 9). The changes visible from test 1–2 to tests 3–4 show how the application of light finger pressure on the gel prior to applying the weight enhanced contact and thus capillary action.

3.2.3. Wool

Wool’s hydrophobic nature reduced the movement of the ink through the textile as its resistance to water limited the degree of wicking (figs. 8-10). This property allowed changes in depth and concentration to have a greater effect on the results of these tests.

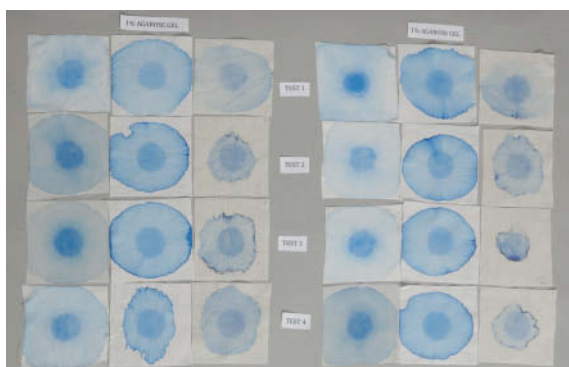


Fig. 8. Results of 1% gels on fabric substrates. Movement of ink through fabric samples. 0.5 cm gel samples are on the left and 0.3 cm gel samples on the right. Fabrics are laid out from left to right, always in the order of silk, cotton, and wool.

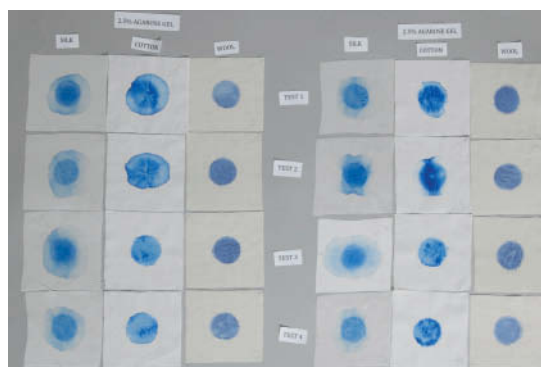


Fig. 9. Results of 2.5% gels on fabric substrates. Movement of ink through fabric samples. 0.5 cm gel samples are on the left and 0.3 cm gel samples on the right. Fabrics are laid out from left to right, always in the order of silk, cotton, and wool.

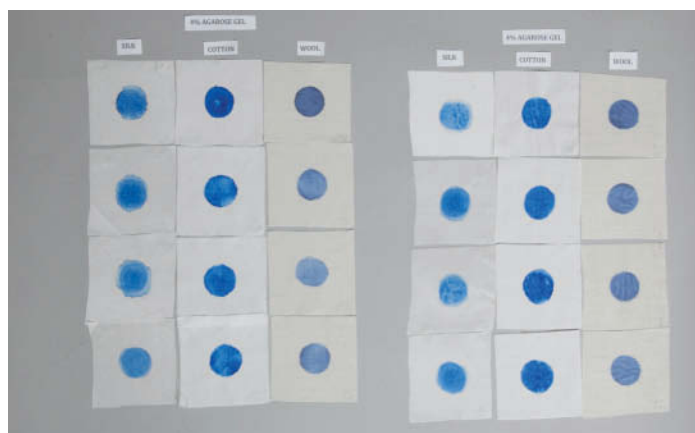


Fig. 10. Results of 4% gels on fabric substrates. Movement of ink through fabric samples. 0.5 cm gel samples are on the left and 0.3 cm gel samples on the right. Fabrics are laid out from left to right, always in the order of silk, cotton, and wool.

3.2.4. Absorption of ink

The amount of ink absorbed into the gels differed for each textile and concentration. Concentrations of 2.5% and 4% exhibited more absorption of ink than the 1% gels. The uptake was, however, unevenly distributed through the gels (figs. 6, 11). Ink uptake was usually associated with points of good contact between the gel and the textile. Fiber-specific information was difficult to gauge from the gels, as the amount of ink applied to each fabric differed and thus the results across fiber types are statistically nonviable. Based on the color of the gel, with darker gels indicating a higher concentration of ink, 2.5% gels absorbed the most ink. As this is a cross concentration comparison including all fiber types, this conclusion has merit. 2.5% gels were able to solubilize the ink and maintain a balance of capillary action without flooding outward into the textile.

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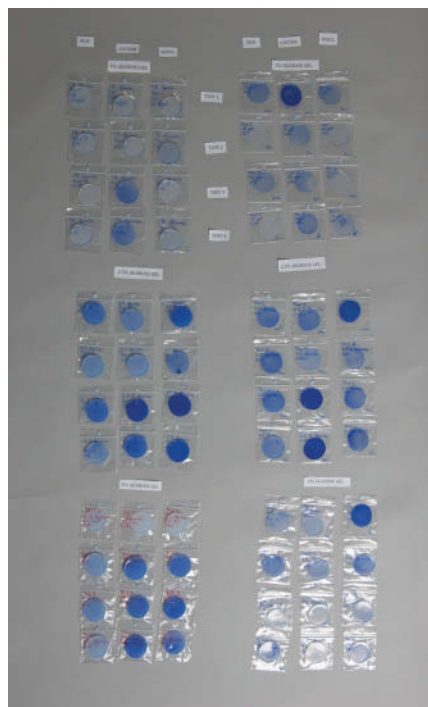


Fig. 11. Movement of ink into gels. 0.5 cm gel samples are on the left and 0.3 cm gel samples on the right. Order mirrors that of the fabric samples.

3.2.5. Contact

1% gels indicated better surface contact on all textiles, as exhibited by the weave imprint of the surface of the gel. This contact decreased as concentration increased. 4% gels exhibited the least contact, with very little fiber imprint visible on the surface of the gel. 2.5% gels fell between these two results: good contact was achieved, though the imprint of the weave was not completely visible across the entire surface of the gel. Issues with contact were observed after the first two test cycles of 2.5% gels. At this point, light finger pressure was applied to the gels prior to weighting, and both contact and capillary action were greatly improved (fig. 9).

4. DISCUSSION

4.1. THE EFFECT OF FIBER TYPE

Fiber type is one of the most important factors affecting the diffusion of moisture through a fabric. In this research it was seen to influence the rates of diffusion and capillary action of the gels tested. For silk, a strongly hygroscopic fiber, the fabric absorbed moisture from the gel preferentially even at 4%, leading to wicking and tidelines at the point of evaporation. This would suggest that when using agarose gels on silk, it would be beneficial to consider the application of a barrier to limit lateral movement of the gel solvent into the textile. This has been successfully achieved on wool using cyclododecane (Sahmel et al. 2012).

For wool, the rates of diffusion and capillary action appeared to be balanced at concentrations of 2.5% and 4%, as results for these tests exhibited minimal wicking of moisture into the textile. This suggests that agarose gels might be considered for use independently, i.e., without a barrier layer, on wool and other similar fibers.

It is, however, important to stress that there are many other factors which impact the rates of diffusion, such as fiber processing, fabric structure, the presence of finishes, soiling, and staining. It was out of the scope of this research to examine the effect of these variables, but they would be necessary considerations in any practical application.

4.2. THE INFLUENCE OF CONCENTRATION

Across all substrates, 1% gels showed extensive ringing and tidelines, with very little absorption back into the gel; it is therefore suggested that 1% gels are not ideal for use on textile substrates without a barrier. It might be argued that a 2.5% gel would be overall more effective in most treatment situations, reducing risk and achieving better capillary exchange.

In general, the results of these tests indicated that gels of a higher concentration (2.5% or 4%) that had good contact with the substrate resulted in strong capillary action and limited preferential diffusion into the fiber. The 2.5% gels offered the best contact with the textiles; their flexibility allowed them to bend and conform to the weave structure, encouraging the formation of a system of diffusion and capillary action imperative to poultice treatments. The rigid 4% gels could not achieve contact with the textile to the same degree, limiting the overall effectiveness of diffusion and capillary action.

It is also important to consider that a gel of higher concentration cannot be used with some additives such as enzymes, as the small pore size would be too restrictive. Furthermore, the property of wettability must be considered when forming gels with any additive or cleaning product, as their addition may change the surface tension of the water within the gel and hence the wetting out of the substrate.

4.3. THE EFFECT OF GEL DEPTH

Decreasing the depth of gel reduced the volume of water held within the gel matrix, thus further limiting the movement of water through the textile substrate. Reducing the depth of a gel could therefore aid in controlling a poultice on more hygroscopic materials. This variable can be used in conjunction with concentration to achieve ideal contact and capillary action without flooding the substrate.

4.4. LIMITATIONS OF THE RESEARCH

The results of the experimental phase broadly fulfilled the aims of the research. However, it is important to acknowledge that the scope of the testing was limited and that the observations made would benefit from further, more targeted investigation. The fabrics tested were new and although they were consistent in terms of weave count, they were not identical. Only water was tested as a solvent. Although this provides a baseline standard that helps in understanding how diffusion and capillary action work under the conditions tested, further experimental work into the use of other solvents or additives would be useful. Length of treatment, the use of barriers, and the influence of textile condition on the application method and results are all areas of further research.

5. CONCLUSION

There is great potential for the use of agarose as a rigid gel poultice in textile conservation. This project has contributed to the body of knowledge about the physical and chemical properties of agarose, and through preliminary testing, has indicated how agarose gels work on different textiles at different depths

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and concentrations. Although there is much scope for further research at an academic level, and it is always necessary to undertake extensive object-specific testing, it is hoped that the information gathered during the project will be of benefit to conservators who are considering using agarose.

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SOURCES OF MATERIALS

Molecular Biology Grade A9539

Sigma-Aldrich Company Ltd.

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www.sigmaaldrich.com/united-kingdom.html

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TIPS AND TRICKS TO REMOVE THE MUD FROM TEXTILE COLLECTIONS AFTER A FLOOD

S. GAIL NIINIMAA

ABSTRACT—Extreme flooding in southern Alberta, Canada, in June 2013 resulted in collection damage to the Museum of the Highwood. Some initial recovery was done in July 2013, but the bulk of the textile collection was frozen, thawed, and wet-cleaned from January to June of 2014. When faced with the conservation of over 500 muddy and flood-damaged textiles, traditional conservative methods of textile conservation treatment needed to be modified. This article discusses the treatment methodology and how resilient the textiles were in more aggressive treatments. Lessons learned in this salvage operation are shared.

RESUMEN—Las inundaciones extremas en el sur de Alberta, Canadá, en junio de 2013 resultaron en daños a la colección del Museo del Highwood. El rescate inicial se realizó en julio de 2013, pero la mayor parte de la colección textil se congeló, descongeló y lavó entre enero y junio de 2014. Frente a la conservación de más de 500 textiles fangosos y dañados, era necesario modificar los métodos tradicionales de conservación de textiles. Este artículo discute la metodología de tratamiento y la resiliencia de los textiles ante tratamientos más agresivos. Se comparten las lecciones aprendidas en esta operación de salvamento.

1. BACKGROUND

On June 20, 2013, flooding occurred in southern Alberta, Canada, submerging the storage facility of the Museum of the Highwood in the town of High River. Prior to the Fort McMurray, Alberta, fires in May 2016, this disaster in southern Alberta was the costliest weather-related disaster in Canadian history. The unprecedented flooding occurred as a result of a deluge of rain, which created a supersaturated ground condition, compounded by the release of meltwater from the mountains where the headwaters of the Highwood and the Sheep Rivers originate (fig. 1a). With little warning, both the basement of the museum and the off-site storage area were filled with river water. All 13,000 residents of High River were evacuated and the town remained



Fig. 1. (a) Street flooding on June 20, 2013, and (b) the collection being laid out for salvage on July 6, 2013. Courtesy of Irene Kerr.

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inaccessible for 11 days. On July 1, once access was granted, director/curator Irene Kerr and summer student Olivia Cotton Cornwall were the only staff available from the Museum of the Highwood to deal with this disaster. Belfor Restoration, hired by the town of High River, was able to begin to remove the water from the storage from July 2–4. Kerr and Irene Karsten, sent by the Canadian Conservation Institute on July 4, coordinated the salvage efforts. It was evident that considerable resources would be required to salvage the collection due to the magnitude of the disaster (fig. 1b).

2. INITIAL SALVAGE

In the initial days after the floodwaters rushed in, calls were made to the museum community for help. Kerr coordinated the efforts of the volunteers who came, in addition to the workers that Belfor Restoration provided. On July 4, the water had been pumped out, and Karsten and the conservation and salvage crews led by Belfor Restoration worked with Kerr to organize the operation, despite the heart-wrenching experience of seeing such a well-kept collection suffer such damage. The author, a textile conservator from Niinimaa Enterprises Inc., arrived in High River as a volunteer on July 5, the first morning that textiles were beginning to be removed from storage, and helped where able. As the flooded collection was brought up out of the basement in plastic bags (since the acid-free textile storage boxes were completely soaked), the teams of conservators tried to salvage and deal with the wet, muddy collection (fig. 2).

It was soon evident that the scale of this disaster was overwhelming and that the conservators were not prepared to deal with a flood of this scope and magnitude. On the first day there was only one source of water to share between four conservators. Throughout the following week, a second source of water was found, and teams of conservators and volunteers worked to salvage the collection by rinsing off and drying artifacts on-site, or rinsing, bagging, and freezing the collection for treatment at a future time.

Funding to restore the collections of Alberta Museums flooded in this disaster was allocated by the Alberta Government and administered through the Alberta Museums Association. What was initially thought to be a six-month salvage project was generously extended through to the end of 2016. This has afforded conservators the opportunity to wet-clean the over 500 flooded textiles, to learn from the experience, and to share their findings in the hope that others will be better equipped to handle a future disaster.



Fig. 2. Salvage operation with plastic bins set up on the picnic benches.



Fig. 3. Some of the first 75 textiles wet-cleaned in the pop-up backyard laboratory.



Fig. 4. Box of Boy Scout uniforms, interleaved with tissue paper, frozen in a mass without rinsing.

One of the most interesting reflections on this project concerns how well textiles recovered from the basement and cleaned on the same afternoon turned out. Initially, conservators tried to perform salvage operations on the street in front of the museum storage facility, but it was an extremely difficult work environment, prompting the removal of approximately 75 textiles to a backyard pop-up cleaning laboratory where there was more control and less chaos. The results of wet-cleaning the initial 75 using only Orvus WA Paste (sodium lauryl sulfate detergent) were overall quite good. The soiling was removed, and remarkably, the textiles were clean to an acceptable standard (fig. 3).

The salvage effort continued for the next week with numerous volunteer hours and paid workers. During this initial salvage operation, the on-site teams rinsed the mud off the textiles, wrapped some in spun bonded polyester film, bagged them in plastic bags, and placed them in a large freezer truck. Due to the sheer scale of the disaster, some of the textiles salvaged were not rinsed, but placed directly into the freezer—mud, tissue paper, and all (fig. 4).

3. SECOND PHASE OF SALVAGE

In January 2014, Niinimaa Enterprises was contracted to help with the cleaning of the textiles, which had been frozen since July 2013. The freezer truck was costing the museum \$2,000 per month to operate, so it was time to begin the task of emptying it. A plan was made to get the collection thawed, wet-cleaned, and stable enough to return to the museum's storage. A small but efficient laboratory space was found located five minutes from the freezer truck (fig. 5). For the washing project, two deep, restaurant-style sinks and a small wash sink were set up in addition to multiple plastic bins. A grease trap was added to the water outflow from the sinks to help remove the silt before it could enter the water system.

When the salvage from the freezer truck began, one of the challenges was the lack of a detailed inventory of the boxes, which meant that it was not always possible to know what was in the frozen mass or how many items were in the box until it was completely thawed.

The river water that flooded High River originated in the Rocky Mountains, and the silt was comprised of clay loam. There was very little oil or toxic material in the water, but a great deal of fine sediment penetrated the contents of the basement storage area. The water stayed in the storage area for 14 days until it was pumped

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Fig. 5. Laboratory that was set up for the wet-cleaning operation.

out the day before the salvage operation began (fig. 6). This sequence of events resulted in no mold growth appearing on the textile collection since the textiles largely remained submerged and were damp for only a short period.



Fig. 6. First glimpses of the state of the off-site storage. Courtesy of Irene Kerr.

3.1. WET-CLEANING SOLUTION

It should be noted that wet-cleaning was performed on textiles that were already in either a wet or a frozen state. The drastic treatments were considered necessary due to the extreme amount of dirt on the textiles and the fact that they had been immersed in muddy, silty river water for an extended period of time. The goal of the initial cleaning was to remove enough sediment that the textiles could be returned to the museum storage facility.

The early pieces retrieved from the freezer were wet-cleaned using traditional protocols with gentle soaking, sponging with Orvus WA Paste, and rinsing. This method was not effective enough to remove the fine silt that was embedded in the fibers (fig. 7).

After a few weeks of unsatisfactory cleaning results, discussions with textile conservator Kathy Francis and conservation scientist Richard Wolbers about how to improve the wash procedure led to the addition of the chelating agent DTPA (diethylenetriaminepentaacetic acid) into the wet-cleaning solution. 10–20 mL of 40% w/v DTPA solution were added per liter of pre-made 2% w/v Orvus, resulting in a final solution with approximately 0.4–0.8% w/v DTPA. The addition of the chelating agent helped to sequester metal ions from the river silt, drawing them into the wash water and moving them away from the textile fibers. The Orvus's high sulfate concentration (sodium sulfate) helped to swell fibers to release dirt, and its strong detergency (sodium lauryl sulfate, hydrophile-lipophile balance 40) and foaming capacity (lauryl alcohol) worked well to release and suspend the river silt. Natural sponges were soaked in the DTPA/Orvus solution and used to wet-clean the textiles. The high sudsing action of the Orvus combined with the chelating agent DTPA helped to move the fine silt out of the textile fibers and suspend it in the water.

3.2. SALVAGE AND WET-CLEANING PROCEDURE

The project was tackled in the following way:

1. Retrieval of the box from the freezer truck.
2. Photography and listing of the contents of the box as much as possible.
3. Immersion of frozen textiles in a plastic bin or sink full of water to begin the thawing process (fig. 8).
4. Post-thaw separation of the contents and further identification of the textiles and separation into smaller, more manageable batches.



Fig. 7. Silk bodice after wet-cleaning using traditional methods and Orvus WA Paste.



Fig. 8. Laboratory setup with multiple bins to thaw the frozen textiles. Courtesy of Rebecca Delorme.

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5. Gradual renewal of the muddy water until the water in the bath was “clean” enough to begin the wet-cleaning process.
6. Wet-cleaning of thawed items either separately or together, depending on the items, e.g., if there were two christening gowns or similar types of costumes, they may have been wet-cleaned in the same batch.
7. Once the majority of the mud and silt had been removed, spraying the sturdy wool, cotton, and linen costumes with water from a hose and garden spray nozzle to help dislodge the dirt that had become embedded in the fibers (fig. 9).
8. Soaking to prepare the textiles for wet-cleaning.
9. Wet-cleaning with Orvus WA Paste, DTPA, and tap water.
10. A second wet-cleaning was usually completed.
11. Thorough rinsing: sometimes up to seven rinses were needed.
12. Blotting with towels, and blocking out or hanging to dry depending on the textile.

This project allowed the opportunity to wet-clean flood damaged textiles in three different contexts. The first context was the 75 textiles that were removed on the first day of salvage and never frozen, but kept wet and wet-cleaned within the next three days. The second context was approximately 500 textiles that were frozen and wet-cleaned after being retrieved from the freezer truck—some of these were cleaned using only Orvus and some also had the chelating agent DTPA added to the cleaning solution. The third context was to re-visit some of the textiles and to wet-clean the more historically significant pieces in the collection for a second time. This secondary wet-cleaning also included the use of Orvus and DTPA.

3.3. MAJOR WET-CLEANING FINDINGS

Aggressive action is required to loosen fine silt sediment from fibers. It is unknown whether the freeze/thaw action that happened in the freezer truck affected the way the silt adhered to the textiles. Successful cleaning occurred when the textiles were soaked, sprayed, and soaked another time prior to adding the wet-cleaning solution. The addition of DTPA was very effective, especially with wool and silk. The luster and sheen of the silk seemed to improve more after being wet-cleaned with the addition of DTPA (fig. 10). With woolen fibers, a considerable amount of silt was removed with the Orvus WA Paste/DTPA solution.

In the case of the extremely muddy textiles, it was necessary to wet-clean them a second time. It was surprising how much additional dirt was removed from the textiles in these secondary cleanings, especially in



Fig. 9. Effects of spraying: right side of the dress has been sprayed after soaking.



Fig. 10. Silk bodice after second wet-cleaning with DTPA added to the Orvus solution.

the costumes made of wool. Several World War I uniforms were in this group, and had significant amounts of silt removed from them with the second cleanings (fig. 11). This is likely due to a combination of factors: the densely woven structure of wool, the wool required more wetting due to its hydrophobic nature, and the first treatments may not have been aggressive enough.

3.4. TYPES OF TEXTILES TREATED

The collection was comprised of late 19th century and up to mid-20th century cultural items from the settlers and early pioneers of the High River area. The earliest textile in the collection was from the 1870s.



Fig. 11. World War I uniform undergoing second wet-cleaning. The sink on right shows the accumulation of dirt in the water after the first soak, and the sink on left is being filled with clean water.

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Fig. 12. Top hat, before and after wet-cleaning. Left courtesy of Irene Kerr.

In addition to a variety of men's, women's, and children's clothing, there were several quilts, embroideries, and accessories such as beaver top hats (fig. 12), military hats and accessories, dolls, and stuffed animals.

3.5. CHALLENGES

There were several challenges encountered during this project. One of the biggest challenges was that many of the catalogue numbers attached to the artifacts had only been written on paper tags. During the 14 days submerged in water, many tags had disintegrated, leaving textiles disassociated from their numbers, or if the tags were still intact, portions of the tri-part numbering system had disappeared (fig. 13). In addition to wet-cleaning the collection, a great deal of detective work and record-searching was also required to determine the pieces' correct numbers.

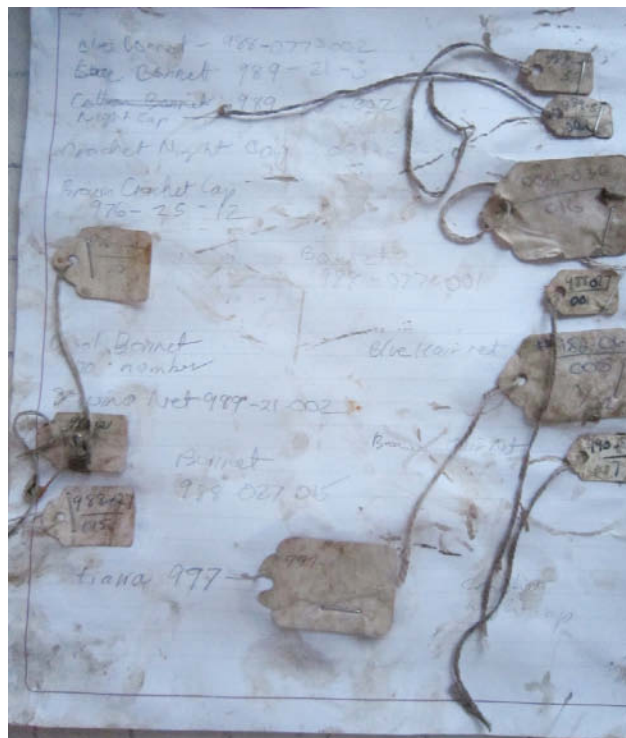


Fig. 13. Paper numbers and the challenge of dealing with the identification of the collection.



Fig. 14. Tissue paper layered on a bundle of four beaded dresses, wet and clinging to the silk, attracting dirt (left), and tissue paper from the pile of Boy Scout uniforms in figure 4 (right).

Tissue paper was used in storage for interleaving, and this became problematic when wet and muddy. The dirt and silt seemed to be attracted to the tissue paper, and areas of the flooded textiles were dirtier where tissue paper was in contact with them. Since tissue paper loses all strength when wet, there was an additional challenge to safely remove the tissue paper from the artifacts and ensure that the wads of wet tissue paper did not clog the plumbing system (fig. 14).

Photodocumentation was used extensively, but it became a challenge in this flood recovery situation since working with wet hands in combination with textiles, mud, and electronic equipment is problematic. The team would have benefitted from having a dedicated photographer to capture images in the midst of the wet, muddy treatments.

4. CONCLUSIONS

1. Documentation is invaluable and it is very important to photodocument everything. From the beginning, any tags that may have been associated with the textile were also photographed; this was useful later when trying to reassociate the textiles with their catalogue numbers.
2. Dissociation issues that occurred underscore the importance of basic photographic records and descriptions of each collection piece, along with up-to-date inventories of collections by shelf and location.
3. Keeping track of the volume of pieces was daunting, and weekly logs of the box numbers taken from the freezer were included in the treatment records. Not all of the items in the boxes had an identifiable catalogue number, but by piecing all of the information together, the puzzle could usually be solved.
4. In retrospect, a standalone database of conservation treatments would have been very useful and saved time over the course of the project. Excel spreadsheets were created, but there was a lot of time wasted looking for information.
5. Communicate and share to avoid duplication of effort. The team used the online file hosting service Dropbox to hold documents so that everyone had equal access to them, and to help people know which was the latest version of the project.

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6. Once the funding was extended, conservators were able to use AnyDesk, a remote desktop application, to connect with the museum's collection database from the off-site laboratory. This was very useful in determining what pieces had been treated and what had been lost in the flood.
7. On-site recovery actions by others will impact your work. If possible, find a space that will allow for the salvage work to happen away from the chaos of the recovery operation.
8. Use of tissue paper as interleaving for storage needs to be rethought as it is not a suitable product for flooded collections. Products such as non-woven spun bonded polypropylene may be a better choice.
9. It is really important for people to understand the overall goals of the project and to work together as a team to achieve those goals. A salvage operation of this scale is challenging and it is necessary for everyone to work together to accomplish the task.
10. If possible, try to wet-clean textiles immediately after they are salvaged from a disaster. Although freezing can buy time when needed, it also may affect how dirt is attracted to textiles, making it more difficult to remove compared to the initial opportunity.
11. Some of the textiles had large amounts of frost on them when they were first retrieved from the freezer truck, suggesting that there was some freeze/thawing occurring during the six to eight months in the truck. The freezer truck that was available was limiting, and it was located outside in 30°C summer weather for a few months. The location of the freezer truck and stability of the freezing temperatures may be a consideration to ensure that the frozen textiles remain frozen.
12. In the case of extremely dirty textiles from severe flooding, the first treatment may not be the last. However, in some cases, if the spraying and soaking had been more aggressive initially, the first cleaning may have been more successful.
13. Textiles are extremely resilient. Many types or combinations of textiles that traditionally may not be wet-cleaned were immersed in water, yet appeared to suffer no ill effects. Observations from this project have shown that we can pursue more aggressive treatments in the laboratory if we are confronted with textiles that are extremely dirty, and that sometimes this type of treatment is the only way that a textile can be salvaged (fig. 15).



Fig. 15. Dress after being removed from the freezer, and after wet-cleaning using the complete protocol.

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SOURCES OF MATERIALS

Spun Bonded Polypropylene Non Woven Style 900-SB 050 or 900-SB 220

Testfabrics
415 Delaware Ave.
PO Box 26
West Pittson, PA 18643
Tel: (570) 603-0432
Fax: (570) 603-0433
www.testfabrics.com

Diethylenetriaminepentaacetic Acid Pentasodium Salt Solution, 40% in Water (DPTA)

17969-500 mL
Sigma-Aldrich Canada Co.
2149 Winston Park Dr.
Oakville, ON L6H 6J8
Canada
Tel: (905) 829-9500
www.sigmaaldrich.com

Orvus WA Paste

Proctor & Gamble
UFA
High River Farm & Ranch Supply Store
2006 10 Ave. SE
High River, AB T1V 2A6
Canada
Tel: (403) 652-2112
www.ufa.com/products/orvus-soap

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EXPLORING ORIGINS: THE TECHNICAL ANALYSIS OF TWO YORUBA MASQUERADE COSTUMES AT THE NATIONAL MUSEUM OF AFRICAN ART

REBECCA SUMMEROUR AND ODILE MADDEN

EXTENDED ABSTRACT

Egúngún masquerades are traditions in which composite ensembles are worn and danced to commemorate ancestors in West African Yoruba communities. This technical analysis of two 20th century Egúngún in the collection of the Smithsonian's National Museum of African Art (NMAfA), referred to as 2005-2-1 and 2009-15-1 (figs. 1, 2), investigates materials in these colorful costumes.

The Yoruba are a cultural group rooted in southwestern Nigeria, Benin, and Togo with a diaspora in Africa and the Americas. In their traditional belief system, Egúngún are the embodiment of lineage ancestors. Fully concealed maskers incarnate individual or collective spirits, providing opportunity for the deceased or those yet to be born to connect with their communities. Typically brought out during annual Egúngún festivals, they perform various tasks while accompanied by singing, chanting, and drumming. They dance with athletic swirling motions, honoring their ancestral strength and power (Drewal and Drewal 1978; Pemberton 1978; Schiltz 1978; Babayemi 1980; Drewal et al. 1989; Aremu 2005; Lawal 2007; Lawal 2012; Campbell 2015; Drewal 2015; Lawal 2015b).

The NMAfA Egúngún were acquired by the museum in 2005 and 2009. Both are attributed to mid-20th century Nigeria, with provenance dating to ca. 1980 and ca. 1998, respectively. The two Egúngún are constructed similarly. Each has a fabric-covered horizontal wooden headboard. Sewn onto this is the body of the ensemble, which is in three layers. The innermost layer is primarily pieced *aso oke*, a handmade Yoruba



Fig.1. Masquerade costume (Egúngún), Yoruba peoples; Nigeria; Mid-20th century; cloth, wood, metal, plastic; H × W: 170.2 × 129.5 cm (67 × 51 in.); Museum purchase, 2005-2-1; National Museum of African Art, Smithsonian Institution.

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Fig. 2. Masquerade costume (Egúngún), Yoruba peoples; Nigeria, Mid-20th century; cloth, plastic, wood; Flat: $175.3 \times 121.9 \times 10.2$ cm ($69 \times 48 \times 4$ in); Gift of Art U. Mbanefo; 2009-15-1; National Museum of African Art, Smithsonian Institution.

fabric. Next are skirts of pieced plain-weave factory print cloth with red as a dominant color. The exteriors are adorned with numerous patchwork lappets that are made primarily of fabrics, but also include materials such as adhesive, plastic film, and aluminum foil. Pins and buttons are attached to the front central lappets.

Approximately 300 fabrics were documented on each ensemble. Irene Emery's book *The Primary Structures of Fabrics* (1980) was consulted to classify the fabrics. Time restraints limited classification to general types such as velvet, satin, and printed plain weave. Materials analysis included polarized light microscopy (PLM), x-ray fluorescence spectrometry (XRF), Fourier transform infrared spectroscopy (FTIR), and Raman spectroscopy. These techniques identified cotton, wool, silk, regenerated cellulose (viscose), and cellulose acetate fibers, as well as polyvinyl chloride (PVC) and cellulose acetate films, and steel and aluminum metal alloys.

The NMAfA Egúngún materials and construction were compared with 12 ensembles in three other collections: two at the Virginia Museum of Fine Arts, three at the North Carolina Museum of Art, and seven at the Indianapolis Museum of Art. Seven of these ensembles share materials and construction techniques that, based on visual examination, suggest they may be from the same mid-20th century era as the NMAfA Egúngún. Lurex components that appear integral to the other five suggest they may have been assembled later. Lurex was developed in 1946 (Lurex 2016), but only gained popularity in Africa in the 1970s (Picton 1995; Clarke 1997). Also, some ensembles include machine embroidered fabric called "African lace," which became popular in Nigeria in the 1960s and remains so (Plankensteiner 2010). Additionally, stamps or printed text indicate origins for four of the textiles. A silk velvet was made in Germany, while three printed cotton plain weaves were made in France, Ivory Coast, and the People's Republic of China. In three of these instances, this information is on selvages that are used decoratively.

This project found that the materials and their relationships to the costumes can advise historical timelines for Egúngún. While components could potentially have been saved for years before the Egúngún were assembled or added during years of use, their technology can establish a *terminus post quem* of their addition. For the NMAfA Egúngún, regenerated cellulose (viscose) and cellulose acetate fibers are informative. Both were discovered in the 19th century but became commercially available in the first two decades of the 20th century. Industrial manufacture increased in the 1930s and '40s and was further refined in the 1950s (Fiorentini Capitani and Ricci 1994; Coleman 2003; Harrop 2003). Cellulose acetate and PVC films were commercially available before 1930 (Shashoua 2008). The thorough integration of the extruded fibers suggests the ensembles were likely made no earlier than the 1930s–1950s.

Other materials support mid-century attributions, including a PVC film on 2009-15-1 that appears to contain the Coca-Cola logo (fig. 3). Coca-Cola was introduced to Nigeria in 1951 (Nigerian Bottling Company Ltd. 2016). On 2005-2-1, one pin-back button is an “L & K Mineral Waters” advertisement featuring 1950s world champion Nigerian boxer Hogan Bassey (fig. 4) (Mee 1998), another has the Yoruba text “Ominira Iwo Orun Nigeria Soju Emi 1957,” which translates to “Self-government in Western Nigeria happened in my lifetime 1957” (Lawal 2015a), and an aluminum alloy attachment contains the text “NPC,” which might refer to the “Northern People’s Congress” (Lawal 2015b), a Nigerian political party from 1949 until 1966 (Esposito 2016). The absence of newer materials, such as acrylic, polyester, and Lurex, might potentially be meaningful as Yoruba arts are ever evolving and incorporating new materials (Picton 1995; Clarke 1997), and Egúngún in other collections were found to include newer materials. Minimal specific text was found on the NMAfA Egúngún that could pinpoint origin or context of these textiles.

Egúngún are complex assemblages that inform understanding of their technology and history as well as broader perceptions of culture, trade relationships, status, and meaning. Previous studies on Egúngún include descriptions of constituent textiles, but until now, no published technical study has focused on Egúngún. Challenges include the large number of fabrics that are fragmentary and often partially obscured by incorpo-



Fig. 3. Plastic film used as serrated edging on 2009-15-1 that appears to contain the Coca-Cola logo.

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Fig. 4. Lappets with pins and buttons on 2005-2-1. At left is the “NPC” button. At right are the “L & K Mineral Waters” advertisement with 1950s world champion Nigerian boxer Hogan Bassey as well as the button with Yoruba text.

ration into lappets. Direct study is also complicated by the size, weight, and fragility of Egúngún, and the fact that museum examples are few. Here, hundreds of fabrics in two Egúngún were physically documented from a conservator’s perspective, and scientific analysis helped identify materials and establish timelines for the ensembles. Future research could include more detailed structural analysis of fabrics as well as comparisons to manufacturers’ fabric swatch books and trade catalogues. Interviews with African market vendors could share knowledge of fabric origins. Lastly, analysis of other 20th century materials, such as faux leather and braided trim, in Egúngún in other collections could be an instructive line of research. It is hard to overstate the importance of textiles in Yoruba culture, making this a compelling area for further work.

Note: A 10-page article on this topic will be published by the Textile Society of America (TSA) in open access format with papers from the TSA’s 2016 Symposium *Crosscurrents: Land, Labor, and the Port*. This project was nominated for the Founding Presidents Award at that symposium.

RESUMEN—Un estudio técnico de dos Egúngún—ensamblajes de mascarada de los yoruba—del siglo XX en el Museo Nacional de Arte Africano del Smithsonian (NMAfA) investiga materiales en estos trajes coloridos. Aproximadamente 600 tipos de tela se clasificaron, incluyendo terciopelo, raso, algodón impreso y *aso oke*—un textil yoruba tejido a mano. Algodón, lana, seda, rayón viscosa y fibras de acetato de celulosa; películas de policloruro de vinilo (PVC) y acetato de celulosa; y aleaciones metales de acero y de aluminio se identificaron por microscopía de luz polarizada (PLM), espectroscopia de fluorescencia de rayos X (XRF), espectroscopia infrarroja por transformada de Fourier (FTIR) y espectroscopia Raman. Los materiales y la construcción se compararon con conjuntos en el Museo de Bellas Artes de Virginia, el Museo de Arte de Carolina del Norte y el Museo de Arte de Indianapolis. Los materiales pueden establecer un *terminus post quem* para su incorporación, sin embargo los componentes podrían ser más antiguos que los Egúngún o haber sido agregados después de años de uso. Se encontró muy poco texto específico en los Egúngún del NMAfA que pudo identificar el origen o el contexto de los conjuntos.

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VIAL THINGS: PRESERVING THE UNEXPECTED IN THE OCCULT JEWELRY OF SIMON COSTIN

SARAH SCATURRO

EXTENDED ABSTRACT

Vials of evaporating semen and decaying, greasy turkey claws—these are not things usually associated with high fashion. Yet just like modern art, contemporary fashion is created from unexpected materials often designed to shock and titillate, thus creating unique challenges for fashion conservators. Recently, two necklaces by the British designer Simon Costin, held in The Metropolitan Museum of Art's Costume Institute collection, underwent examination, treatment, and storage rehousing in order to address issues related to the preservation of the biological specimens integrated into them. The first necklace, titled *Incubus* (1987), is composed of copper wire, silver sperm motifs, and five glass vials filled with semen and mounted in partial silver casings. The conservation challenges presented by this necklace were primarily related to storage, since an interview with the artist revealed that the semen had been evaporating slowly over the past three decades. Inspired by preservation methods typically used for fluid-preserved biological specimens, innovative solutions were explored including the use of micro-chambers, anoxia, cyclododecane, microcrystalline wax, and cold storage. The second necklace, titled *Memento Mori* (1986), contains two taxidermied turkey claws and three rabbit skulls, along with Victorian lace, wooden beads, and hematite. The challenge for this necklace was twofold: the turkey claws and rabbit skulls had been improperly prepared and were subsequently exuding grease and showing mold respectively, and the necklace was also found to have been infested. Informed by methods used in natural history collections, the treatment and storage solutions for this necklace explored degreasing methods and long-term anoxia. The preservation campaigns for both objects underscore the requirement for a multiplicity of approaches for the conservation of contemporary fashion, the necessity to engage with other conservation disciplines in order to find effective solutions, and the benefit of conducting a designer interview in order to deepen understanding of artistic intention.

RESUMEN—Al igual que el arte moderno, la moda contemporánea puede ser creado a partir de materiales inesperados diseñados para impactar y estimular, creando desafíos únicos para los conservadores de moda. En Instituto del Traje en el Museo Metropolitano de Arte, dos collares del diseñador británico Simon Costin se sometieron a examen, tratamiento y almacenamiento para abordar la preservación de sus especímenes biológicos integrados. Un collar, *Incubus* (1987), presentó un desafío de almacenamiento: una entrevista con el artista reveló que el semen contenido dentro del collar se había evaporado lentamente. Inspirado por los métodos de preservación usados para muestras biológicas preservadas, se exploraron soluciones innovadoras incluyendo el uso de microcámaras, anoxia, ciclododecano, cera microcristalina y almacenamiento en frío. El segundo collar, *Memento Mori* (1986), presentó un doble desafío: su taxidermia—garras de pavo y cráneos de conejo—había sido preparado incorrectamente y estaba exudando grasa y mostrando moho respectivamente, y el collar también demostró indicios de infestación. Informado por los métodos utilizados en las colecciones de historia natural, los tratamientos de desengrasado y la anoxia a largo plazo se exploraron. Las campañas de preservación de ambos objetos subrayan la multiplicidad de enfoques necesarios para la conservación de la moda contemporánea, la necesidad de colaborar con otras disciplinas de conservación para encontrar soluciones efectivas y el beneficio de las entrevistas con diseñadores para profundizar la comprensión de la intención artística.

VIAL THINGS: PRESERVING THE UNEXPECTED IN THE OCCULT
JEWELRY OF SIMON COSTIN

AUTHOR BIOGRAPHY

SARAH SCATURRO is the head conservator of The Costume Institute in The Metropolitan Museum of Art. She was previously the textile conservator and assistant curator of fashion at the Cooper-Hewitt, Smithsonian Design Museum. Most recently, Sarah co-authored “Inherent Vice” in *Charles James: Beyond Fashion* (2014), and was the guest editor for the special issue on “Curating Costume/Exhibiting Fashion” for the *Journal of Fashion, Style and Popular Culture*. She received an MA in fashion and textile studies from the Fashion Institute of Technology, a BA in history and Italian from the University of Colorado, Boulder, and is currently pursuing a PhD at Bard Graduate Center.

FIRST AID STRATEGIES OF RARE ANCIENT EGYPTIAN TEXTILES IN EXCAVATION

HARBY E. AHMED

ABSTRACT—The excavation of Tuna el-Gebel was a scientific joint venture between the Institute of Egyptology of the University of Munich, Germany and the University of Cairo, Egypt. The ibis burial place at Tuna el-Gebel, located at the west of the ancient city of Thermopolis Magna, has been the first, and for a long period, the only, ibis and baboon animal cemetery during the reign of Pharaoh Pasetkheh (664–619 BC). Among the findings of the excavations, several pieces of rare textiles were unearthed. These textiles were found in a poor state of conservation and risked further deterioration if left untreated. A close examination of the textile was followed by various nondestructive analyses in order to develop a treatment plan. This research shows the practical strategies that have to be followed in maintaining and conserving textiles. The effects of cleaning materials on the natural dyes were tested. Dry-cleaning was used to remove resistant stains and dirt. The process of maintenance and restoration was recorded step by step, beginning from the historical record of the textile to the cleaning process. In addition, the process of mounting the pieces in preparation for display or storage in a museum is described.

RESUMEN—La excavación de Tuna el-Gebel fue un proyecto científico colectivo del Instituto de Egiptología de la Universidad de Munich, Alemania y la Universidad de El Cairo, Egipto. El lugar de enterramiento de ibis en Tuna el-Gebel, situado al oeste de la antigua ciudad de Thermopolis Magna, ha sido el primero y durante mucho tiempo el único cementerio de ibis y babuino durante el reinado del faraón Pasetkheh (664-619 AC). Entre los hallazgos de las excavaciones, se descubrieron varias piezas de textiles raros. Estos textiles se encontraban en un estado de conservación malo y corrían el riesgo de más deterioro si no se trataban. Después de un examen minucioso del textil, se realizaron varios análisis no destructivos para elaborar un plan de tratamiento. Esta investigación muestra las estrategias prácticas que son necesarios para mantener y conservar los textiles. Se probaron los efectos de los materiales de limpieza sobre los colorantes naturales. La limpieza en seco se utilizó para eliminar las manchas resistentes y la suciedad. El proceso de mantenimiento y restauración fue registrado paso a paso, desde el registro histórico del textil hasta el proceso de limpieza. Además, se describe el proceso de montaje de las piezas en preparación para su exhibición o almacenamiento en un museo.

<http://www.conservation-us.org/docs/default-source/annualmeeting/42-first-aid-strategies-of-rare-ancient-egyptian-textiles-in-excavation.pdf>

AUTHOR BIOGRAPHY

HARBY E. AHMED is associate professor of historical textiles conservation at Cairo University. He started his training at the Conservation and Restoration Institute in Kina, Egypt, where he obtained a diploma degree in 1993. He later obtained bachelor's (1997) and master's (2002) degrees in conservation and restoration at Cairo University, and a PhD on the use of enzymes for the conservation of textiles from the National Technical University of Athens, Greece in 2010. He is the author of seven books published in Europe and Egypt, and has authored more than 21 articles in international journals. He conserves a large number of historic textiles in Egyptian museums, excavations, and outside Egypt in Middle Eastern countries. He is supervisor of more than 18 master and PhD theses. E-mail: harbyezzeldeen@cu.edu.eg.

A MOUNT FOR PREVENTION IS WORTH A POUND OF CARE: REHOUSING FESTIVAL HATS AT THE TEXTILE MUSEUM OF CANADA

HILLARY ANDERSON AND GENEVIEVE KULIS

ABSTRACT—The Textile Museum of Canada's collection of over 240 Chinese festival hats is considered one of the museum's most iconic collections. Appreciated for their whimsical appearance and ornate decoration, these hats are also important for the cultural narrative to which they contribute. Due in part to the use of elaborate and extensive decorative elements on a sensitive material substrate (silk), the objects have become structurally tenuous. In order to mediate this issue, the Textile Museum of Canada began a rehousing project to create a mounting system that can be used for both storage and display purposes. The new system was designed to enable various individuals (staff, interns, and volunteers) to create these mounts successfully while simultaneously working within given budgetary, material, and time constraints. This poster presents the materials and methods used during the development and fabrication of these mounts. The conservation benefits and outcomes of the rehousing project are also touched upon, including the ability of the mounts to reduce current structural stresses to the hats, the prevention of future damage due to direct handling and mishandling of the objects, and the enhanced ability to monitor the collection for potential future threats.

RESUMEN—La colección de más de 240 sombreros chinos del Museo Textil de Canadá es considerada una de las colecciones más emblemáticas del museo. Apreciados por su apariencia caprichosa y decoración ornamentada, estos sombreros también son importantes para la narrativa cultural a la que contribuyen. Debido, en parte, al uso de elaborados y extensos elementos decorativos sobre un sustrato de material delicado (seda), los objetos se han vuelto estructuralmente tenues. Con el fin de mediar en esta cuestión, el Museo Textil de Canadá comenzó un proyecto para crear un sistema de montaje que se puede utilizar tanto para el almacenamiento como la exposición. El nuevo sistema fue diseñado para permitir que varios individuos (personal, pasantes y voluntarios) creen estos soportes con éxito, mientras que simultáneamente los soportes funcionan dentro de restricciones presupuestarias, materiales y de tiempo. Este cartel presenta los materiales y métodos utilizados para su desarrollo y fabricación. También se abordan los beneficios de la conservación y los resultados del proyecto de re-almacenaje, incluyendo la capacidad de los soportes para reducir las tensiones estructurales actuales de los sombreros, la prevención de daños futuros debidos a la manipulación directa y mal tratamiento de los objetos, y la capacidad mejorada de monitorear la colección contra posibles amenazas futuras.

<http://www.conservation-us.org/docs/default-source/annualmeeting/45-a-mount-for-preservation-is-worth-a-pound-of-care—rehousing-festival-hats-at-the-textile-museum-of-canada.pdf>

AUTHOR BIOGRAPHIES

HILLARY ANDERSON joined the Textile Museum of Canada (TMC) in 2012 as the museum's conservator. She first volunteered at the TMC in 2004; though she originally intended only to volunteer for a summer, instead she stayed for five years. That experience inspired her to pursue textile conservation as a profession, and she graduated from Fleming College's Collections Conservation and Management program in 2011. She also holds a degree in fashion design from Ryerson University in Toronto. Her previous experience includes a

HILLARY ANDERSON AND GENEVIEVE KULIS

textile conservation internship for Historic Royal Palaces in England and assisting in the conservation of a historic banner owned by the Charitable Irish Society of Halifax. E-mail: handerson@textilemuseum.ca.

GENEVIEVE KULIS is a conservator from Toronto with an interest in object and natural history conservation. She has a Bachelor of Arts from McGill University, with a major in anthropology and a minor in earth and planetary sciences. In 2014 she graduated from the Cultural Heritage Conservation and Management program at Fleming College. Since graduating, she has worked at the Textile Museum of Canada as a conservation assistant and privately, as a public art conservator, for the City of Toronto. She is currently employed at the Royal Alberta Museum as a natural history conservator. E-mail: ggkulis@hotmail.com.

SENDING CLAM SHELLS ACROSS THE ATLANTIC: PREPARING THE ALEXANDER MCQUEEN RAZOR CLAM DRESS FOR LOAN

CASSANDRA GERO

ABSTRACT—In 2011, The Costume Institute at The Metropolitan Museum of Art put on the immensely popular exhibition, *Alexander McQueen: Savage Beauty*, curated by Andrew Bolton. When the Victoria and Albert Museum (V&A) mounted their own version of the show, they borrowed The Costume Institute's iconic razor clam dress, entitled *Voss*. The dress, from McQueen's spring/summer 2001 collection, is covered in approximately 1,200 razor clam shells that are sewn to the dress with monofilament. The shells are fragile and heavy, making the dress difficult to handle. The monofilament often fails, dropping shells when the dress is manipulated. Due to the difficulty encountered in mounting the object, the dress was shipped to the V&A on a mannequin. This made installation easier, but packing much more challenging. This poster details the internal packing that was required to keep the shells from crashing against each other and the fiberglass mannequin while inside its crate. Custom Tyvek and polyester batting pads, tissue, and other materials were used to pad the shells and keep them safe and stable for travel. The packing process and custom crate were ultimately successful, and the dress made it safely to London and back.

RESUMEN—En 2011, el Instituto del Traje en el Museo Metropolitano de Arte presentó la exhibición inmensamente popular, *Alexander McQueen: Belleza Salvaje*, curada por Andrew Bolton. Cuando el Museo Victoria y Albert (V&A) montó su propia versión de la exposición, tomaron prestado el vestido icónico hecho de conchas de muergos del Instituto del Traje, titulado *Voss*. El vestido, de la colección de primavera/verano 2001 de McQueen, tiene 1.200 conchas cosidos al vestido con monofilamento. Las conchas son frágiles y pesadas, y es difícil manejar el vestido. El monofilamento falla a menudo, dejando caer la conchas cuando el vestido se manipula. Debido a la dificultad encontrada en el montaje del objeto, el vestido fue enviado al V&A en un maniquí. Esto facilitó la instalación, pero hizo mucho más difícil el embalaje. Este cartel detalla el empaque interno del cajón de embalaje necesario para prevenir que las conchas se choquen contra ellas mismas y el maniquí durante el traslado. Se usaron almohadillas de bateo de poliéster y Tyvek, papel de seda y otros materiales para cubrir las conchas y mantenerlas seguras y estables. Al final, el proceso de empaquetado tuvo éxito, y el vestido viajó sin incidentes de ida a Londres y de vuelta a Nuevo York.

<http://www.conservation-us.org/docs/default-source/annualmeeting/43-sending-clam-shells-across-the-atlantic—preparing-the-alexander-mcqueen-razor-clam-dress-for-loan.pdf>

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FEELING A LITTLE BLUE (GREEN): EFFORT TO REDUCE STAINING ON A FLOOD-DAMAGED ZUNI TEXTILE

CATHLEEN ZARET

ABSTRACT—In 2011 and 2012, a Cargill grant made it possible for the National Museum of the American Indian (NMAI) conservators and fellows to conduct a place-based education program with Pueblo and Navajo communities in the Southwest. During both visits, the team met Zuni master potters Milford and Randi Nahohai. As the Nahohai family shared their process of creating pottery, an ongoing relationship of friendship and trust developed. In 2012, the Nahohai family asked the visiting conservators if they would examine and attempt to reduce stains on a flood-damaged family textile. This was an opportunity for NMAI to do a favor in kind, giving back to the community. In 2013 as a new Mellon Fellow, the author was entrusted with the treatment of their textile, a *meha*. The goal of treatment was to improve its appearance, enabling the family to again wear the textile during religious ceremonies. Mindful of the challenge and conscious of the weight, responsibility, and honor caring for this family heirloom held, many treatment options were carefully pursued. This poster examines the processes and techniques used in the effort to reduce discoloration and staining due to the migration of dyes from colored wool embroidery yarns onto a white cotton ground.

RESUMEN—En 2011 y 2012, gracias a una beca de Cargill, los conservadores y Fellows del Museo Nacional de los Indios Americanos (NMAI) llevaron a cabo un programa de educación con comunidades Pueblo y Navajo en el suroeste. Durante dos visitas, el equipo se reunió con los Zuni alfareros maestros Milford y Randi Nahohai. Cuando la familia Nahohai compartió su proceso de creación de cerámica, se desarrolló una relación de amistad y confianza. En 2012, la familia Nahohai preguntó a los conservadores visitantes si examinarían e intentarían reducir las manchas en un textil familiar dañado por inundaciones. Esta fue una oportunidad para que NMAI hiciera un favor en especie, aportando a la comunidad. En 2013, en su rol de Mellon Fellow, la autora se encargó del tratamiento del textil, un *meha*. El objetivo del tratamiento era mejorar su aspecto, permitiendo que la familia vuelva a usar el textil durante ceremonias religiosas. Teniendo en cuenta el desafío y consciente del peso, la responsabilidad y el honor de cuidar a esta reliquia familiar, se perseguían cuidadosamente muchas opciones de tratamiento. Este cartel examina los procesos y técnicas utilizados en el esfuerzo para reducir la decoloración y las manchas debido a la migración de tintes desde el bordado de lana colorido al tejido de algodón blanco.

[http://www.conservation-us.org/docs/default-source/annualmeeting/44-feeling-a-little-blue-\(green\)—effort-to-reduce-staining-on-a-flood-damaged-zuni-textile.pdf](http://www.conservation-us.org/docs/default-source/annualmeeting/44-feeling-a-little-blue-(green)—effort-to-reduce-staining-on-a-flood-damaged-zuni-textile.pdf)

AUTHOR BIOGRAPHY

CATHLEEN ZARET had recently completed an Andrew W. Mellon Fellowship in Textile Conservation at the Smithsonian Institution's National Museum of the American Indian and had joined the ranks of textile conservators in private practice when this poster was presented. She graduated in May 2013 from the Fashion Institute of Technology with a degree in Fashion and Textile Studies: History, Theory, Museum Practice, with a concentration in textile conservation, and is currently working for museums and private clients in Washington, DC, Maryland, and Virginia. E-mail: cmzaret@gmail.com.

THE SECTIONAL MANNEQUIN: A UNIQUE APPROACH FOR FIRST NATIONS CLOTHING

CAROLINE BOURGEOIS

ABSTRACT—This poster demonstrates the advantages of made-to-measure sectional mannequins, which are composed of a number of different elements fabricated with a variety of materials and facing fabrics. The sectional mannequin is particularly valuable in the display of First Nations clothing, whose constituent materials and unique silhouettes pose a challenge to more traditional methods of mounting. The sectional mannequin permits components to be inserted into a garment independently, significantly reducing the stress that can occur when a one-piece mannequin is used. As well, the different sections of a composite mannequin can be made with a range of materials such as buckram, metal, and Mylar, depending on conservation requirements and the desired final appearance. The sectional mannequin can be adapted for all kinds of clothing, and is particularly useful when the cut of a garment is unusual, when it is composed of several different elements, or when its materials require special handling. By supporting a garment in its correct silhouette, the made-to-measure sectional mannequin contributes to a better understanding of First Nations clothing.

RESUMEN—Este cartel demuestra las ventajas de los maniqués seccionales hechos a medida, que están compuestos por una serie de elementos diferentes fabricados con una variedad de materiales y tejidos. El maniquí seccional es particularmente valioso en la exhibición de ropa de las Primeras Naciones, cuyos materiales constitutivos y siluetas únicas plantean un desafío a los métodos más tradicionales de montaje. El maniquí seccional permite que los componentes se inserten en una prenda de manera independiente, reduciendo significativamente la tensión que puede ocurrir cuando se utiliza un maniquí de una sola pieza. Además, las diferentes secciones de un maniquí compuesto se pueden hacer con una gama de materiales, tales como bucarán, metal y Mylar, dependiendo de los requisitos de conservación y la apariencia final deseada. El maniquí seccional puede ser adaptado para todo tipo de ropa y es particularmente útil cuando el corte de una prenda es inusual, cuando está compuesto de varios elementos diferentes, o cuando sus materiales requieren un manejo especial. Al apoyar una prenda en su silueta correcta, el maniquí seccional hecho a medida contribuye a una mejor comprensión de la ropa de las Primeras Naciones.

<http://www.conservation-us.org/docs/default-source/annualmeeting/41-the-sectional-mannequin—a-unique-approach-for-first-nations-clothing.pdf>

AUTHOR BIOGRAPHY

CAROLINE BOURGEOIS specializes in the design and fabrication of museum-quality mannequins. She obtained diplomas from Collège Marie-Victorin in fashion design, from the École Nationale de Théâtre du Canada in set and costume design, as well as a bachelor's degree in dramatic arts from the Université du Québec à Montréal. After working for more than 10 years as wardrobe mistress for circus, puppet theatre, theatre, and dance, she obtained a diploma in museology from Collège Montmorency. Since 2000 she has worked at the McCord Museum in costume mounting, collections management, and preventive conservation. She joined the conservation department in 2013 and has been a conservation assistant since 2014.

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TEXTILES FOR EMERGENCY SALVAGE: THE ABSORBENCY OF MICRO-DENIER TEXTILES, AND OTHER STANDARD ABSORBENT MATERIALS

MICHELE PAGÁN

ABSTRACT—The purpose of this research is to advise the art conservation community regarding the choice of microfiber fabrics in emergency situations for the removal of water, soot, and soil from the surface of fragile artifact surfaces. In this research project, microdenier fabrics—with emphasis on those most easily available and best representing the types of synthetic fabrics currently available to conservators—were tested using industry-standard absorbency protocols, including those of AATCC. The fabrics were photodocumented and weighed. Absorbency by both immersion and vertical wicking was tested, and test results were compiled. Fiber content (percentage of polyester and nylon) and fabric structure (woven, knitted, nonwoven) were the key indices used as the basis for comparison. All of the microdenier fabrics outperformed the standard denier fabrics in terms of moisture uptake, as measured by both immersion absorption and wicking capability. Of 27 fabrics tested (17 microdenier and 10 standard denier fabrics), the microdenier samples—all of them knitted—displaced more air, and adsorbed more water, than both knitted and woven standard denier fabrics. The two nonwoven samples—one microdenier, one standard denier—each outperformed all of the standard denier fabrics.

RESUMEN—El propósito de esta investigación es aconsejar a la comunidad de conservación de arte en cuanto a la elección de telas de microfibras en situaciones de emergencia para la eliminación de agua, hollín y tierra de las superficies de artefactos frágiles. En este proyecto de investigación, los tejidos de microdenier—con énfasis en los más fácilmente disponibles y mejor representando los tipos de tejidos sintéticos actualmente disponibles para conservadores—fueron probados usando protocolos de absorbencia estándar de la industria, incluyendo los de AATCC. Las telas se fotodocumentaron y se pesaron. Se analizaron la absorción por inmersión y la absorción vertical, y se recopilaron los resultados de la prueba. El contenido de fibra (porcentaje de poliéster y nylon) y la estructura de la tela (tejida plana, tricotada, no tejida) fueron los índices claves utilizados como base para la comparación. Todos los tejidos de microdenier superaron a los tejidos de denier estándar en términos de absorción de humedad, como se mide tanto por absorción de inmersión como por capacidad de absorción vertical. De las 27 telas analizadas (17 microdenier y 10 tejidos de denier estándar), las muestras microdenier—todas ellas tricotadas—desplazaron más aire y adsorbieron más agua que las telas de denier estándar tejidas y tricotadas. Las dos muestras no tejidas—uno de ellos microdenier, uno de ellos denier estándar—superaron todos los tejidos de denier estándar.

<http://www.conservation-us.org/docs/default-source/annualmeeting/48-textiles-for-emergency-salvage—the-absorbency-of-micro-denier-textiles-and-other-standard-absorbent-materials.pdf>

AUTHOR BIOGRAPHY

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