

# **Objects Specialty Group Postprints**

## **Volume Twelve**

**2005**



**AIC**

**The American Institute for Conservation  
of Historic & Artistic Works**

# **Objects Specialty Group Postprints**

## **Volume Twelve**

**2005**

**Compiled by Virginia Greene and  
Patricia Griffin**

**Proceedings of the Objects Specialty Group Session  
June 11-12, 2005  
33rd Annual Meeting  
Minneapolis, Minnesota**



**The American Institute for Conservation  
of Historic & Artistic Works**

This publication entitled *Objects Specialty Group Postprints, Volume Twelve, 2005* is produced by the Objects Specialty Group of the American Institute for Conservation of Historic & Artistic Works.

Cover photograph by Sylvia Keochakian.

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The papers presented in this publication have been edited for clarity and content but have not undergone a formal process of peer review.

This publication is primarily intended for the members of the Objects Specialty Group of the American Institute for Conservation of Historic & Artistic Works. Additional copies of this publication are available for purchase by contacting AIC.

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## FOREWARD

The OSG session at AIC's annual meeting in Minneapolis, MN in June 2005 has been compiled into a 12<sup>th</sup> volume of Postprints. The call for papers aimed to connect with the general session's theme of *Documentation*, and to share advances made in practice for object conservators. The session was split into two themes to allow for a subject untouched at OSG session in the past, namely the topic of *Adhesives*. An hour tip session was also organized in collaboration with the RATS specialty group, with the theme of *Sampling Techniques for Analysis*. The tips were short, informal presentations geared towards increasing the communication between conservation scientists and conservators.

The talks centered on Documentation showed a range of emphasis including management, treatments, and examination tools. John R. Watson presented a database having broad relevance to all specializations, which provides us a linking tool for collections care from the present to the past and future. Also using databases, yet specifically linked to a moving project, Rachael Perkins Arenstein and Emily Kaplan shared their methods in tracking 800,000 Native American objects from the National Museum of the American Indian's collection. Sari Uricheck and Judith Levinson presented their work on surveying Carl Akeley's complex dioramas in the American Museum of Natural History – an impressive project preserving a unique type of museum object.

Two of the presentations related to the documentation theme are not included in the Postprints, however they are worth mentioning. Nancy Hairston from VanDuzen Archives and conservator Joanna Rowntree showed how 3-D scanning using laser technology could be an effective, non-invasive means for examination and documentation. Judith Bischoff presented a technique that she and her colleagues have developed using digital imagery to document microscopy analysis.

A bridge to the next theme was provided by Shelley Reisman Paine's presentation involving both documentation and adhesives. She showed how the numerous components of a ceramic tile Rhead fireplace were transferred and how this was documented, handled, and treated. Julie Unruh et al. also combined the themes showing their documentation of adhesive types used at the Arizona State Museum's collection. Two talks focused on properties of a commonly used adhesive, Acryloid B-72. Julie Wolfe presented studies made on its use for putty making, and Erik Risser addressed his work on the long-term properties such as creep and cold flow. Also looking at the properties of a particular adhesive, Elzbieta Kaminska and Jane Down spoke about their work researching the deterioration of cyanoacrylate adhesives. Specific to treatment techniques, Sylvia Keochakian and Scott Fulton gave an approach to the reversal of unstable adhesives. In conclusion, Eric Hansen gave a review on the effects of solvents on polymers as related to common resins used by conservators as adhesives. The paper by Paula Hobart, Mina Thompson and Maureen Russell, describing a loss compensation technique using Acryloid B72, originally was presented at the Poster Session. Unfortunately, Eric Risser and Eric Hansen were not able to submit their talks for publication in this volume, and the research carried out at CCI will be published in another format.

The value of publishing these talks, albeit in a non-juried volume, has significant importance in supplying additional resources and communication among our colleagues. The success of this meeting was greatly influenced by the collaboration with the other specialty group chairs, the AIC's Meetings & Design Director, Sheila Paige, and AIC's Director of Specialty Groups, Mary Striegel. I would like to thank Jamie Martin who co-chaired the tip session. The speakers all gave high quality presentations, and I am thankful to those who submitted their papers for the Postprint volume. As always due to her long-term commitment to editing and publishing the Postprints, I am very thankful to Ginny Greene.

Julie Wolfe, OSG Program Chair

## THE TREATMENT AND REINSTALLATION OF A CERAMIC TILE FIREPLACE

Shelley Reisman Paine

### Abstract

This article documents the process required to prepare a ceramic tile fireplace surround made in 1911 for John. J. Meacham by Frederick and Agnes Rhead. The tiles were treated and mounted for the *University City Ceramics: Art Pottery of the American Woman's League* exhibition at the Saint Louis Art Museum, Saint Louis, MO, in June 2004.

The surround was constructed from 280 blue-green glazed earthenware tiles with a landscape frieze of large square incised tiles with multicolor glazes. In 2003, the tiles were removed from the Meacham house and brought to the St. Louis Art Museum. During this process, each tile was numbered and a scale drawing was made of the original installation. The tiles varied in size and weight, but most problematically for the treatment, in thickness.

To prepare the tiles for exhibition, multiple decisions involving the curator, conservator, designer, preparator, fabricators and manufacturers were required to create a safe, stable, removable and aesthetically pleasing installation. This report documents the process required to stabilize, clean, compensate for losses and mount the tiles. The mounting process included applying isolation layers of B-72, developing a process to level each tile, attaching the tiles to a custom honeycomb panel with epoxy, and grouting the surround with custom mortar.

### Introduction

The Meacham fireplace was created by ceramicists Frederick & Agnes Rhead in 1911 in University City, a suburb of St. Louis, Missouri, and is now in the collection of the St. Louis Museum of Art. The tiles were treated and mounted for the exhibition *University City Ceramics - Art Pottery of the American Woman's League*. Conservation and reinstallation of the fireplace took six months, involved the treatment of 280 ceramic tiles and required the development of a mounting system that was both portable and allowed each individual tile to be removed at a later date. The process was complicated by the variable thickness of the handmade tiles, up to 1/2" difference, and by the weight of the tiles, 170 pounds.

### History

Frederick Rhead came to America in 1902 from a renowned family of English ceramicists. Between 1910 and 1911 he and his wife Agnes taught at the Art Academy of the People's University, part of the American Woman's League. Both the League and the University were founded by Edward Gardner Lewis, a magazine publisher, entrepreneur and amateur potter, to foster women's education and participation in the activities of American life. The League offered art classes in response to the popularity of the Arts and Crafts Movement. The University was a

free correspondence educational system for women whose sold Lewis's magazines to gain membership in the American Woman's League. While most students were taught by correspondence, Rhead taught the honor students at the academy in University City, MO.



Figure 1. Frederick Rhead in the Art Academy classroom in University City, MO

Ultimately, Lewis's business ventures failed and the University closed after five years. Rhead left after making the Meacham fireplace surround, and went on to work in many potteries before becoming the art director for the Homer Laughlin China Company, the largest American pottery at the time. He worked there until his death in 1942. During his time at the pottery, he oversaw the development of many types of wares including the colorful Fiestaware.



Figure 2. Frederick Rhead fireplace in the Meacham house, University City, MO

While at University City, the Rheads created sets of tiles that were used as pictorial friezes for fireplace surrounds. A set of ten landscape tiles and 270 matte blue/green tiles were made for John J. Meacham and placed in the living room inglenook of his home in University City. The Meacham fireplace demonstrates their interest in simple lines, incised decoration and matte glazes with naturalistic and stylized motifs.

## Treatment

The treatment project took six months and was completed in three different stages. It began in St. Louis in 2003 when the museum staff removed the surround from the Meacham house and brought it to the St Louis Art Museum. The tiles were faced with Jlar tape, an acrylic adhesive on a clear polyethylene base, and the mortar cut away using a diamond wheel. During this process, each tile was numbered and a scale drawing was made of the original installation. It was then delivered to Shelley Reisman Paine Conservation (SRPC) in Nashville. Once the tiles were treated and installed on their new honeycomb support panels, they were returned to St. Louis for grouting and installation in the gallery

While there were many choices for treatment materials and methods, for this project the need for tiles to be put on lightweight portable supports and to be individually removable ultimately drove many of the decisions.

The majority of the tiles were structurally stable. However, six tiles were broken into two fragments and 260 individual areas of loss to the obverse on 180 tiles revealed the interior clay body. Approximately 30 tiles had complete or nearly complete loss of the fired surface on the reverse. In addition, approximately 80% of the tiles had moderate or major accumulations of the bedding mortar that had not been removed after deinstallation. One tile was missing and had been replaced with a darker blue tile. Minor and moderate pits in the glaze overall appeared to be from fabrication. There were a variety of minor black and brown stains and accretions overall and a thin coherent layer of brown/black smoke residue. The black smoke residue also infused the exposed clay body and grout creating a dark charcoal color.



Figure 3a. Tiles from lower left side of fireplace, before treatment, obverse.



Figure 3b. Tiles from lower left side of fireplace, before treatment, reverse.

Figures 3a and b show the condition of the tile. They are from the lower left corner of the fireplace and include the artists' signature in a tile at the bottom row.

Conservators at the St. Louis Art Museum removed the gross accumulations of soot after the tiles were removed from the Meacham home. Once the tiles reached Nashville, SRPC conservators removed the remaining bedding mortar and cleaned the tiles to remove the embedded soot. All six unglazed surfaces were given two applications of a barrier coating of 17% B-72 Paraloid B-72, methylmethacrylate adhesive, dissolved in acetone applied by brush. The Paraloid B-72 acts as a barrier coat to permit later separation of the tiles from the epoxy adhesive and panel if necessary. Podany (et al. 2001) discussed the use of B-72 as a structural adhesive and as a barrier within structural adhesive bonds and clearly identified the need to use acetone as the solvent in the coating. The use of other solvents renders the glass transition temperature too low for this application. After coating, areas of loss were filled with Milliput epoxy putty and the fills were toned with a base coat of Liquitex acrylic emulsion paint applied through an airbrush. The color of each fill was then adjusted with Golden MSA colors. The use of organic solvents was avoided as much as possible to prevent any absorption into the barrier coat.





Figure 4 – Tiles from left side of fireplace after treatment, obverse.

## Panel specifications

Three 1” thick aluminum honeycomb panels were chosen as the support. These are lightweight yet strong enough both to stay flat and to support the aggregate weight of the tiles, adhesive and grout in a vertical orientation: the total weight after grouting is approximately 400 pounds. The panels were custom-made by MuseumServices Corporation to accommodate the specific requirements of the reinstallation. An integral 3” x 1” aluminum tube extended around the perimeter of the top panel and two sides of the two lower panels to reinforce the edges for the exhibit installation hardware.

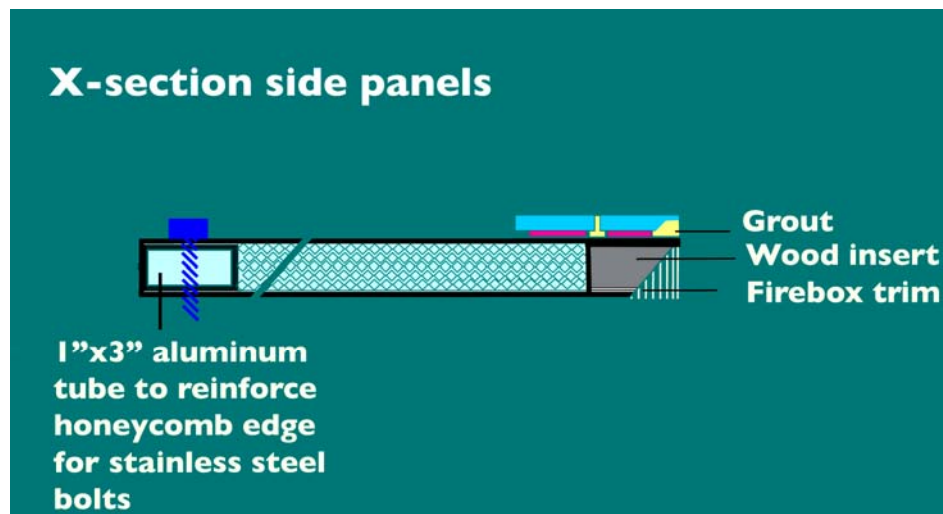


Figure 5. Cross section of side panels

The tiles at the perimeter of the firebox were designed with a beveled reveal under the outermost edge. This bevel created a gap to hold grout that would obscure attachment of the firebox to the surround. Therefore, the interior edge of the lower honeycomb panels included a 45-degree miter and a wood closeout to conceal attachment of the faux firebox in the exhibit installation.

### **Tile installation: Leveling**

Two hundred twenty 3" x 5" and ten 10" x 10" tiles were attached to the panels before grouting and installation. Each tile was leveled separately because none of the handmade tiles were the same thickness. In fact, there was a 1/2" difference between the thickest and thinnest tiles. The leveling process involved the use of wax cones to adjust the height of each tile. Each tile was first placed upside down on a flat board covered with Mylar. Cones of a hard synthetic wax mixture were formed and placed on the surface in regular intervals. The wax chosen was Daige BB9, with a melting point of 180 degF and a softening point of 140 degF. Release paper was placed on each cone before inverting and using pressure to level the tile.



Figure 6. Wax spacers with release paper.



Figure 7. Compressing a tile.



The tiles had to be leveled to match the thickness of the thickest tile. Therefore, each row of tiles was leveled using a carpenter's level that spanned side rails replicating the thickness of the thickest tile. During this process, the cones were compressed into "stilts" that support the tile at the correct height.



Figure 8. Leveling a row.

### **Tile installation: Adhering**

The next step was to adhere the tiles to the honeycomb panels. E.V. Roberts epoxy 4807 and curing agent RF 61 in a ratio of 2:1 were blended with 2% glycerol and fumed silica to get a strong enough adhesive for the project. The glycerol was used to speed the thickening of the mixture at the suggestion of Kevin Zilvar, of E.V. Roberts. The glycerol has 3 hydroxyl groups that form an ionic bond with the Cabosil M5 thus creating a thicker paste more quickly. The adhesive was put in paper cones and piped between the wax stilts.



Figure 9. Epoxy piped between the wax stilts.

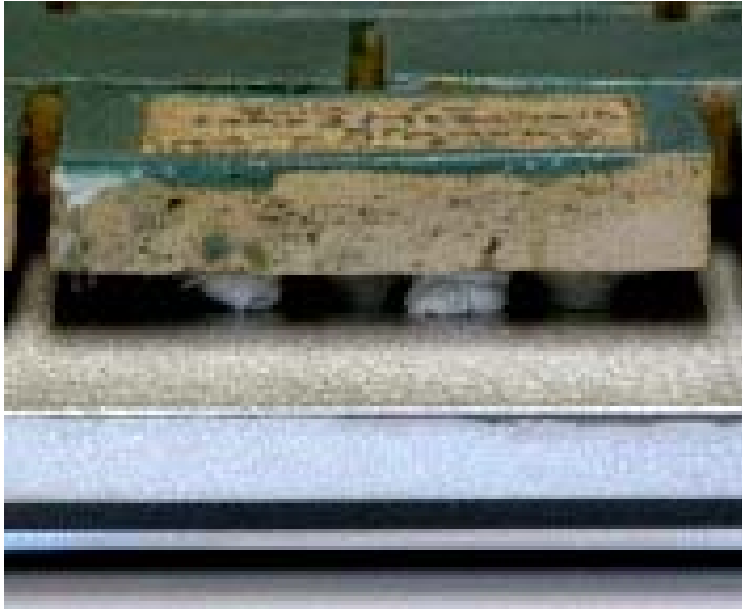


Figure 10. Attachment to the honeycomb panel.

The tiles were then inverted and oriented on the panels. A photo of the surround was used as a reference to recreate their original orientation.

The panels were then crated, picked up by the Museum and returned to St. Louis. There were several reasons to send the panels before grouting. The grout would add significant weight and take 7 days to cure to 90%. Also, moving the tiles prior to grouting prevented the possibility that the grout would crack from exposure to vibration during transit.

### **Tile installation: Grouting**

Once back in St. Louis, the tiles were prepared for grouting and exhibit installation. The process began by applying the Daige wax to the bottom edge of the top panel and the top edge of the two bottom panels. This wax “seam” prevented the grout from adhering to the metal wall support and will help facilitate later separation after the exhibition ends.

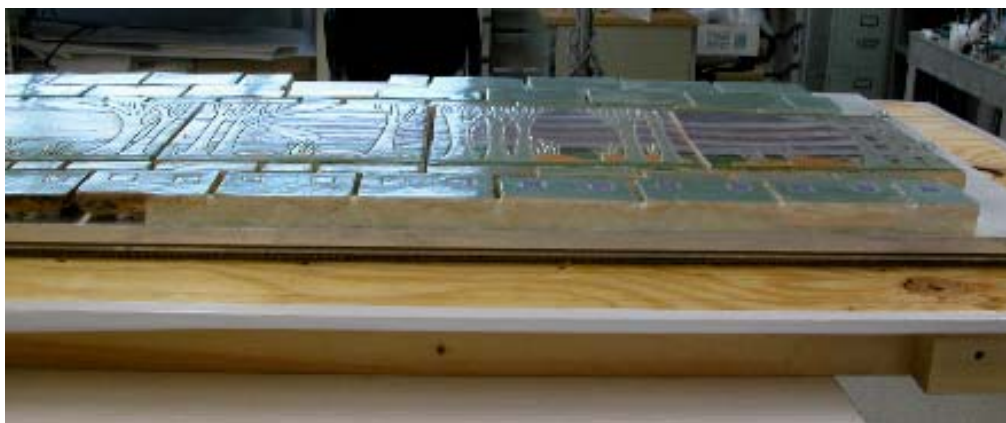


Figure 11 Waxed edge that corresponds to the lower left panel

Traditional grout will not adhere to aluminum. Therefore, Edison custom grout Spec-Joint 46 #10324 with admixture Restoration Latex RL Series was custom mixed to match the original grout texture and color. These materials will adhere to both the B-72 and the aluminum panel. A coating on the obverse of the tile as protection from abrasion during grouting was considered but not carried out for two reasons. First, the inpainting was extensive and had to be done in Nashville. Also, there was concern that during removal organic solvents might be absorbed into the B-72 coating and weaken the barrier film. In the end, there was no apparent abrasion of the tile surface although some grout did penetrate the pits in the tiles. This was removed with no difficulty.



Figure 12. Lower left panel finished and ready to install.

The Museum staff set the hearth in a reinforced bed of leveling mortar and then attached the hearth to the honeycomb panel with the same epoxy used to set the tile.

### Panel installation

There were two primary goals for the installation. First, that the weight of the tile was properly supported, and second, that the original appearance of the surround was correctly interpreted for the exhibition.

The honeycomb panels were designed to attach to the exhibit wall in two ways. First, a series of lag screws and bolts secured the perimeter of each panel to an exhibit wall reinforced with plywood. Second, each panel rested on an angle iron support, attached to the exhibit wall, to distribute the weight of the object. To be certain that the panels remained vertical, the rear edge of each panel was designed with a 3/8" chamfer to accommodate the curve of the angle iron. The thickness of the angle iron is the same as the thickness of the mortar line in the surround. Therefore, the angle iron provided a space for the seam between panels to be grouted. The museum staff then installed a faux surround and firebox created to approximate the original fireplace.

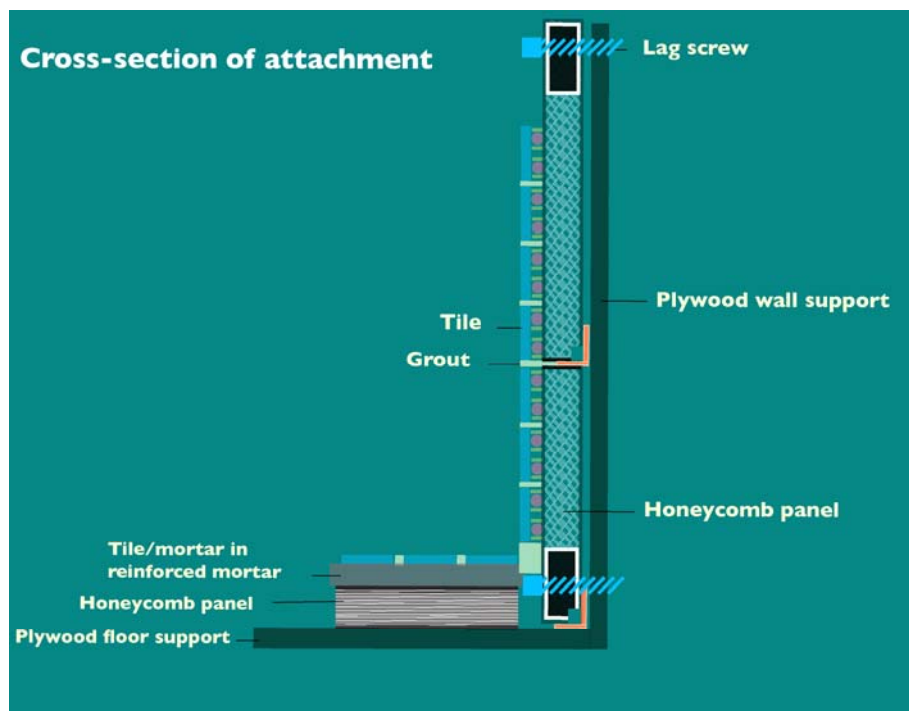


Figure 13. Cross section of attachment.



Figure 14. Panels installed.



Figure 15. Panels installed with surround.

The treatment and installation of the *Rhead Fireplace Surround* was a successful conservation project. It required the use of interesting techniques and materials to create a reversible yet believable installation.

### Acknowledgements

Diane Burke, former object conservator at the St. Louis Art Museum called to ask if the author would conserve the Meacham fireplace. This phone call was the first of many to staff at the St. Louis Art Museum and the beginning of a terrific collaboration. The author would like to thank them all: Diane Burke, Suzanne Hargrove, Zoe Perkins, Peter Wollenberg, David Conradsen, Linda Thomas, Jeanette Fausz, Sheba and Paul Haner, Jeff Wamhoff and Stephen Yusko. Thanks are also due to Kevin Zilvar, E.V.Roberts Adhesive for his technical assistance; Peter Mecklenburg for creating very intricate honeycomb panels; Andrew Lins, conservator, Philadelphia Museum of Art, and Jerry Podany, conservator, Getty Museum, for their support. This project could not have been completed with out the skillful assistance of Patty Grewe-Mullins, assistant conservator at SRPC and Regina Grybos, conservation intern at SRPC.

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Lins, Andrew. Technical notes in, *Dutch Tiles in the Philadelphia Museum of Art* Schaap, Ella and Robert L.H. Chambers, et al., Philadelphia Museum of Art, 1984.

Podany, Jerry, Garland, Kathleen, Freeman, William R., and Rogers, Joe, "Paraloid B-72 as a Structural Adhesive and as a Barrier within Structural Adhesive Bonds: Evaluations of Strength and Reversibility", *Journal of the American Institute for Conservation*, 40 (2001):15-33.

David Conradsen and Ellen Paul Denker, *University City Ceramics: Art Pottery of the American Woman's League*, Saint Louis Art Museum, St. Louis, MO 2004

### Suppliers

Epoxy:

E.V Roberts, 18027 Bishop Avenue, Carson, CA, 90746-4019, (800) 374-3872,  
(www.e.v.roberts.com)

Aluminum panel:

MuseumServices Corporation, 1107 East Cliff Road, Burnsville, MN 55337-1514 ,  
(800) 672-1107, (www.museumservicescorporation)

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## **A CONCEPTUAL MODEL AND PRACTICAL SOLUTION FOR CONSERVATION DOCUMENTATION**

John R. Watson

### **Abstract**

This paper explores the potential of database technology to organize, guide, facilitate, and improve conservation documentation. The example developed by the author, CDS-Documentation (CDS-D), is now published by Conservation Data Systems. The program serves not only as a practical out-of-the-box archival report generator for objects conservation, but also serves as a conceptual model for future documentation software.

Whether documenting conservation of historical objects, fine arts, or natural history specimens, and whether the works are in two or three-dimensions, simple or complex, the building blocks of documentation are the same:

- Project information (object owner, object name, accession number, etc.)
- Components (subdivisions of the object for organizing the following elements of documentation)
  - Description (dimensions, materials, construction, coatings, etc.)
  - Past interventions (restorations and earlier conservation)
  - Condition issues (specific condition problems)
  - Actions (future, present, and past tense: what, if anything, is proposed or was actually done about each condition issue)

These six building blocks link to each other in one-to-many relationships, and can be built up as needed to fit the size and complexity of the project. Thus, one object can have several components, each with optional description and past interventions, and perhaps several condition issues. Each condition issue prompts one or more actions, including, for example, a proposed treatment, actual treatment, or a decision not to treat. Two other building blocks can be linked as needed to any of the others:

- Images (digital images, slides, radiographs, sketches, etc.)
- Analysis (type, method, sample description, results and interpretation)

Database technology handles this type of modular data structure in ways not possible with word processors. CDS-Documentation shows how software can guide conservators toward documentation that complies with our published guidelines. It can arrange any amount of information for any complexity of project in highly organized reports that can be printed on archival paper or captured as digital files to be linked to collections management systems. By exploiting the potential of computer automation, documentation software saves time, improves thoroughness, and provides every possible automation amenity for recording information.

## The CDS Documentation System

This paper proposes a database approach to documentation. Designed by the author and now published by Conservation Data Systems (CDS), the program is called *CDS-Documentation*, or CDS-D [1]. The system was designed according to recommendations in the AIC Standards of Practice [2], and it takes advantage of information technologies to improve the clarity and coherence of our reporting. The premise may seem at first somewhat different from the most common documentation approaches, but it should be measured by what documentation is intended to accomplish. Among other practical considerations, that important purpose is to protect the integrity of the information physically encoded in objects even as we necessarily *alter* the object in the name of stabilization and restorative conservation.

There is a traditional sequence of our reports that includes sections on (1) description, (2) condition, (3) treatment proposal, and (4) treatment. These elements may sometimes group in various ways to produce one, two, or three reports, sometimes combining the first three under the heading “Examination”. While the grouping of the elements may vary, the sequence of them is logical.

Description	Condition	Treatment Proposal	Treatment
~~~~~	~~~~~	~~~~~	~~~~~
~~~~~	~X~~~~~	~~~~~	~~~~~
~~~~~	~~~~~Y~~~~~	~~~~~	~~~~~X
~~~~~	~~~~~	~~~~~	~~~~~
~~~~~	~~~~~	~~~~~X~~~~~	~~~~~
~~~~~	~~~~~	~~~~~	~~~~~Z~~~~~
~~~~~	~~~~~	~~~~~	~~~~~

Figure 1. The traditional conservation report sequence.

The following perhaps familiar experience explains the potential difficulty with this traditional approach to documentation. An object is coming into the lab for conservation. You check the object folder consisting of a hodge-podge of papers and hope to find out what was done in a treatment a dozen years ago. If you’re lucky, you find the full sequence of reports, and begin to read.

The conservator mentions condition problem “X.” Did she treat X? You need to know, so you skip ahead to find out. Treatments are in a different section, and they are covered in a different order than the condition section so you are looking for a needle in a haystack. You do find something in the treatment *proposal* that is probably X, although the language and context is so different you are not sure. So you read on to see what was actually done to treat condition X, and finally locate it in the treatment report. Although connecting Condition X with its related treatment proposal and final treatment presented a challenge it nevertheless proved possible. The same is not true for issue Y, which consumes another five minutes of searching with no success



in finding any treatment proposal or final treatment. Did the conservator just want you to know about condition Y, and judged not to treat it, or did she forget to treat Y or forget to document that she treated Y? Your confidence in the report is shaken when you realize how much of the information lacks correlation between specific condition issues and the conservator's judgments or treatments in response to them.

The most radical proposition in this paper is that conservation documentation should maintain a direct relationship between a specific condition problem and the conservator's judgment or other response to that issue. We will call the response an "*Action*", and consider that a proposal to treat, an actual treatment, and a judgment *not* to treat are all actions.

The relationship between a condition problem and the conservator's action toward it is similar to double entry accounting in the financial world, whereby every credit is balanced by a corresponding debit (eg. Fig. 2). Businesses use double entry accounting not only to help themselves keep track of money, but so others looking in can get the full picture. Violating the integrity of that dual relationship between debit and credit is called sloppy accounting at best, and "cooking the books" or cheating the shareholders at worst. For conservators, future generations are also shareholders, and they deserve to have a coherent picture when they examine our reports.

Date	Accounts	Debit	Credit
June 8	Cash	50.00	
	Revenue		50.00

Figure 2. Double-entry accounting.

The old approach to conservation reports with its overall-object level segregation of information, has come to us from the typewriter age. Typewriters were unable to dynamically assemble information with complex relationships. Segregation of information was a practical necessity. When computers came into the conservation laboratory a couple decades ago, few thought of it as more than an improved typewriter.

Computers can, however, show several types of information in linked relationships: One artifact, several components. For each component, several condition issues, and for each condition issue, one or more actions, and to any of the above, possibly some linked photos. Of the three most common types of computer software (word processors, spreadsheet software, and database programs) which technology can handle that?

Word processors are the direct descendents of the typewriter, and have always been the popular choice. We are familiar with them, and they work well typing old-style reports with their freely structured discussions of condition and treatment. Word processors, however, cannot easily handle more than one or two levels of relational data without running aground.

CDS-Documentation shows how relational database technology can solve the coherence problem in documentation. The program also makes use of computer automation to organize information, generate reports, and greatly enhance the data entry process.

For the simplest projects, CDS-D provides a “Short Form” is provided. This illustrates how the program uses automation to save time and improve the quality of reports. Just how much time the program saves, depends on first teaching it a few things about your lab, and how you work: A number of buttons on the screen (Fig. 3) provide automated features that draw on your own customizations entered into the program’s setup. Often-re-used information can be entered once in Setup, and thereafter be available for point and click selection. You can customize the pick-lists of condition issues, of conservation materials, and of object materials. Enter your lab’s name, your staff, and a custom report header and the automation will begin to pay off.

CDS-Documentation: Conservation Data Systems, LLC - [Short Form]

File Find View Reports Tools Help

CDS-Documentation — Short Form

Id Photos (0) Project Photos (0)

Object Name \_\_\_\_\_ Project No. \_\_\_\_\_

Object Number \_\_\_\_\_ Project Type \_\_\_\_\_

Measurements  \_\_\_\_\_ Object Mat'l's  \_\_\_\_\_

Description \_\_\_\_\_

Condition \_\_\_\_\_

Standard Procedure  \_\_\_\_\_ Cons. Mat'l's  \_\_\_\_\_

Treatment \_\_\_\_\_

Graphic Folder  \_\_\_\_\_

Staffing  \_\_\_\_\_

Signatures  \_\_\_\_\_

☐ Use as Template ☐ This Record is Complete

Tmt. Hrs. \_\_\_\_\_ Tmt. Date \_\_\_\_\_

31 31 Copyright © 2002-04 CDS, LLC

Record: 11 of 11

The name of the object. \_\_\_\_\_

Figure 3. CDS-D Short Form.

A simple repair, such as the reattachment of a small molding on a wooden box, demonstrates the Short Form. The text boxes at the top of the form are for the basic object identification, and the three largest boxes are labeled “Description”, “Condition,” and “Treatment.” In this way, the Short Form simply follows the traditional sequence of report segments, but with some time-saving automation. Some of the boxes are already filled out with information you previously designated as “default,” including the conservator’s name, and the titles of the people who will need to sign the report. The form takes a very few minutes to fill, and creates an appropriately brief printed report.

The highly *routine* conservation of a single-piece iron object might be almost identical to hundreds of other similar projects that come through the lab, and automation becomes even more important. In the CDS-D Short Form, 4 clicks reveal a list of templates you have previously designed, and you select the one for “Small Iron Objects”. Three more clicks, and the Short Form appears with most of the report already filled in, including the detailed treatment procedure, conservator’s name, report signatories, preventive conservation recommendations, project type (ex. “Examination and Treatment”); object materials; and even some likely condition language. Now tweak the condition language that came with the template and some minimal typing of the object name, number, measurements, and description. Enter a date in the “Completion Date” box, or double click there and the current date appears automatically. Enter your treatment time, and you can mark the record complete. Because this treatment used one of your pre-defined “standard procedures,” there is no further treatment information to type.

If you had an ID photo or two, you could link them into the report with four to six clicks. Any amount of other digital photo-documentation can be linked as well. The photo cataloging form gives a place to add a caption that will be printed with the photo in the report, or if you used 35mm slides, the captions print on slide labels. In four more clicks, the report is printed. It takes about two minutes to create this routine report, start to finish.

In one more Short Form example, the object has three condition issues, and although they are combined into one condition textbox, they are numbered, and the treatment textbox uses the same three numbers to maintain the important link between each condition issue and the corresponding action. You can do that with a word processor too, of course, and even if you continue using word processors for documentation, matching numbers in condition and treatment sections can at least maintain an issue-by-issue link. The project has two ID photos and three other photographs, and its report assembles all the information into a three-page report including photos.

CDS-Documentation can thus quickly handle the smallest jobs and the most routine jobs, but it is equally equipped to handle much larger, and more complex treatments. As reported in the General Session of the 2005 AIC Annual Meeting in Minneapolis by Joe Sembrat of Conservation Solutions, Inc., the program is being used on what may be the largest and most complex treatment in North America, a Saturn V rocket; longer than a football field, and weighing over six million pounds.

The strategy for documenting this and much more modest size projects, is the same. The familiar sequence of documentation steps (description, proposal, and action), will need to work like

building blocks that can be assembled as needed to build any size structure. We rely heavily now on database technology to maintain the sequence at the *component* level.

The first building block is the basic Project/Object Identification form. It is the only multi-page form in the program, but the most important text boxes are on the first page. The occasional red asterisk next to a text box (the object title in this instance) tells where data *must* be entered for the program to work. It is very important to know the remaining majority of text boxes are for your convenience, should you choose to use them. They also serve as reminders of the types of information that are consistent with the standards of practice for documentation.

An object is, of course, usually made up of several components. Any logical breakdown can work if it will make recording more efficient. Although usually consisting of a physical part of the object, a “component” can also be a side, section, material type, or an area marked on a location map—anything that helps break the report into more manageable parts. CDS-D color codes the forms so the blue forms refer to the overall project, and the buff forms refer to whatever component is selected in the component window. You can identify any number of components, and arrange them in a hierarchy of up to four levels. Description, Condition, or Action records each also have a “location” field to further specify precise locations within the component to which it is linked.

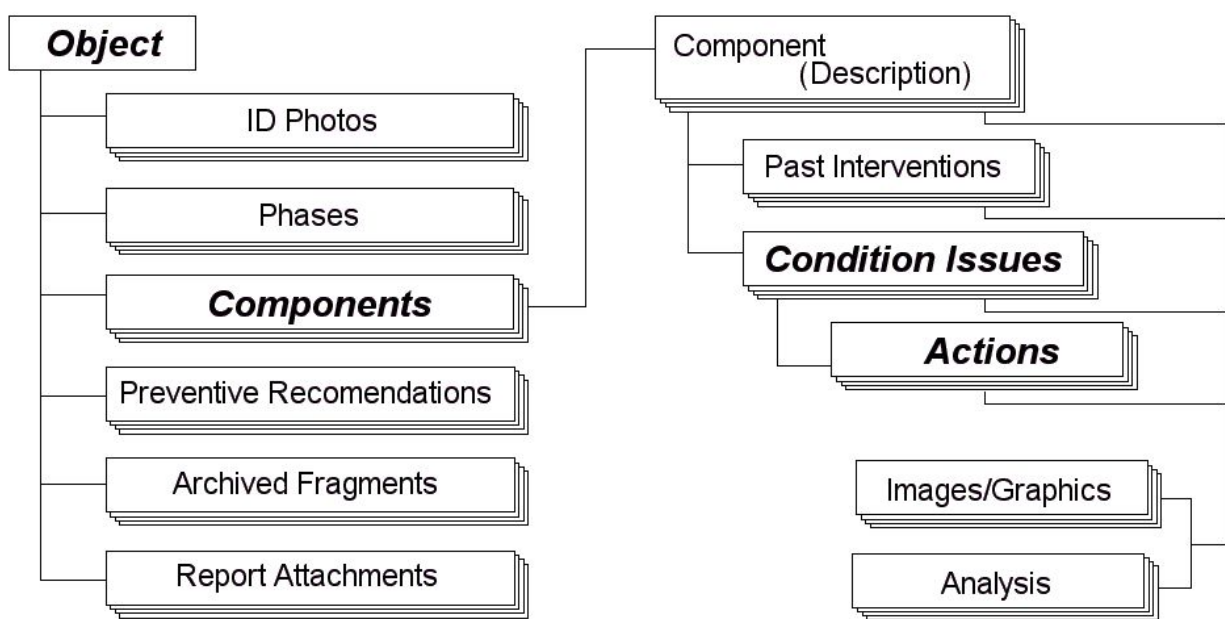


Figure 4. The CDS-D information structure.

The diagram in Fig. 4 shows the building blocks of CDS-Documentation, with their one-to-many relationships to each other. The bold print labels show the core structure: one project (object) can have multiple components, and each component can in turn, have multiple condition issues, each of which can prompt one or more responses or “actions.”

Interventive conservation projects tend to be undertaken on either a *remedial* or a *comprehensive* level. Attention in remedial projects is limited to condition problems and their treatment, while a comprehensive approach can involve observations and recording of more information: object materials, aesthetic characteristics, material evidence, past restoration and other past interventions and condition issues not actually requiring treatment.

CDS-D accommodates either approach, providing a place for one or more *past interventions* at the component level. Intentional alterations, restorations, repairs, as well as past conservation treatments can be recorded here, whether or not they result in condition problems to be treated. We are sometimes tempted to withhold our interpretations out of scholarly rigor because we could be wrong. The design of the program makes it acceptable to make an educated guess as to what was done in a past intervention, because a text box is also provided for recording the evidence on which we base our interpretation, however strong or weak the evidence may be. In this way, future investigators have the benefit of our interpretation, but can judge its veracity for themselves. Known *campaigns* of past restoration or conservation can be recorded in the system. Then as you come to evidence of another past intervention, the identified campaigns appear in a dropdown list for attachment to the intervention. This is especially useful when you are consolidating information from various old reports and documents into a single comprehensive report.

The heart of the documentation program is the Condition Issue form. There can be any number of condition issues for each component, and a location text box allows you to be specific about the affected area for each. The condition form appears with its companion, the Action form. Again, the only *required* fields are marked with red asterisks. The screen layout symbolizes the relationship: for every condition, there can be one or more action records. In the example, there are two, the first being a treatment proposal, and the second being the actual treatment. The dropdown button on the Action Type reveals what is meant by “action”. The first few items are most common. Even “No Treatment” is a judgment and constitutes an action by the conservator.

The screenshot displays the CDS-D data entry interface. At the top, a menu bar includes 'File', 'Find', 'Reports', 'Tools', and 'Help'. Below this, a tabbed interface shows 'Project', 'Description, Interventions', 'Condition, Actions', 'Attachments', 'Archived', and 'Preventive'. The 'Condition, Actions' tab is active, showing two sub-forms: 'Condition Issues' and 'Actions'.

The 'Condition Issues' form (top) has a title bar with '2116' and icons for attachments and help. It includes fields for 'Unstable' (checked), 'Damage Type' (Pick), and 'Location' (Side of base near bottom). A 'Notes' field contains the text: 'A small plaque has become separated from the base and the nails lost. Witness marks and two nail holes show its correct position. the plaque is inscribed "Pecheur."'.

The 'Actions' form (bottom) has a title bar with '635' and icons for attachments and help. It includes fields for 'Action Type' (Proposed Treatment), 'Cons. Materials' (Pick: Paraloid® B-72), 'Standard Procedure' (Pick (only)), and 'Notes' (Re-attach plaque using new escutcheon nails, undersize escutcheon pins and secure them). A dropdown menu for 'Proposed Treatment' is open, showing options: 'No Treatment', 'Treatment', 'Possible Future Action', 'Treated as Proposed', 'Treatment Rejected', 'Proposal Alteration', 'Further Examination', 'Treatment Option 1', 'Treatment Option 2', 'Treatment Option 3', 'Adaptation', and 'Interventive Investigation'.

On the left side, a 'Components' list shows a hierarchy: 'Overall Lamp', 'Human Figure', 'Flowers', 'Stems', 'Petals', 'Rose Lightbulbs', 'Base' (selected), and 'Other Electrical Parts'. The 'Base' component is highlighted with a red circle. The 'Condition Issues' tab is also circled in red. The 'Actions' tab is circled in red, and the 'Proposed Treatment' dropdown menu is circled in red. The 'Record' field at the bottom shows '1 of 2'.

Figure 5. The CDS-D data entry screen with Condition and Action forms displayed. The action form is linked to the condition issue above it, which is linked to the selected component.

The system also provides a place (see the tabs near the top in fig. 5) to catalog physical fragments, (samples or pieces that could not be reintegrated), and another place to catalog report attachments (analytical printouts, copies of old documents, lab notes, etc.). The Preventive Recommendations form is simple, but includes powerful automation for selecting standardized language from any number of your own categories. It also has a report button right on the form for printing out the recommendations for storing with the object.

**Graphic**

**Action Graphics**

Graphic Type \* **Digital Image** Set as Default Treatment Status **AT** Set as Default Image by **JRW** Set as Default

Commentary The cupped ivory is beneath a layer of Gore-tex. Water is being applied to the top of the Gore-tex, which passes enough moisture to the ivory to straighten the cupping. While flat, and before the ivory cups again, the ivory is reglued to the key lever.

Digital File Name **18341-0161.JPG** Browse

Technical Image Data Nikon 5700 Digital Camera and detached electronic flash

Always Show Graphics ☒ Show/Refresh Graphic -->

Graphic ID 1410 View in Graphic Viewer Edit Graphic Browse All Project Graphics Re-link Digital Images

File Path <V:\Shared\Common\Conservation Archive\Objects\2004-0024\TL\18341\Photos\Small\18341-0161.JPG>

Record: 1 of 1 (Filtered)

Figure 6. The form for cataloging photos and other graphics. This one is labeled “Action Graphics” because it will be linked to a treatment (action) record.

A button with a camera icon is provided on many of the forms. It opens a form for cataloging digital images or other graphics, and it links the image to the current record. Fig. 6 shows the form, this example being linked to a particular action record. A browse button on the form takes you immediately to the folder where your project photos are stored. Point and click to enter a photo, then type a caption with the photo in front of you. Other buttons on the form can open the current photo in an external viewer program or a photo editor program, all from within CDS-D.

Another button on the Description, Condition, and Action forms provides a place to record analysis, and it too is linked to the description, condition, or action form where the button was located



The programmer has provided many other amenities to save time and to make it easy to correct mistakes. If you accidentally enter condition information under the wrong component, for example, you can “cut and paste” it to the correct component, and when you do, all linked action, photo, or analysis records automatically move with it. You can designate the data in some fields as “default.” During an examination, for example, “Action Type” may always be “Proposed Treatment.” When you set this text as the default, it will appear automatically when you double-click in that text box. Touch F7 to run a spell check on any text box. Enter any date in the completion box, or double-click to automatically enter the current date. Many text boxes have drop-down pick-lists for one-click data entry. One button opens a “ToDo” list for reminders specific to the current project. If there are any fields specific to your work that are not provided in CDS-D, use the “auto-text” button next to a text box and enter or select from your list of customized subheadings. The list will always be specific to the text box it is near. There are three popup pick-lists that can be set up in categories. The one in Fig. 7 is for condition issues. Clicking on the Edit button allows you to customize the pick-list for your own specialty.

Physical Damage	Chemical Damage	Biological Damage	Historic Effects
abraded	active corrosion	insect damage	coating additions
accretions	crystalline deposits	mold/fungi	historic deposits
blistered	fading	rot	historic repairs
brittle	light damage	vermin damage	losses/loose/missing parts
broken/fragmented	potentially active corrosion		old labeling
buckled	stable oxides		past alteration
burnt	stain/discoloration		previous conservation
cleavage	sweating/weeping		repairs/restoration
decssicated			rodent damage
detached			
dirt, grime, surface deposits			
distorted/bent/dented			
dull			
dust			
flaking			
frayed			
friable			
glue failure			
losses/missing parts			
materials interface damage			
scratched			
shrinkage			
soot/smoke damage			
spalling			
split/cracked			
structurally unsound			
tenting			
torn			
warped			
wet/damp			

Other
disturbed during treatment
mechanical maladjustment
not observed

Figure 7. The Condition Type pick-list with four condition issues selected.

The condition pick-list helps to sharpen perceptions by serving as a checklist of possible condition problems. Select one or several condition issues and either save them all to the same



condition record, or let the program save the selections to individual condition records so you can record actions separately for each condition.

The program offers thirty different reports, and some can be customized. Most of the time, the comprehensive report is all that is needed. This report contains all the information in the correct relationships. The programmer had a challenging task in creating a report capable of showing the sequence (description, condition, proposal, and treatment) repeated on the component-level rather than the overall object level, while also including photos and analysis records, each in their correct context.

The hierarchical arrangement of information in the report is similar to the table relationships as illustrated in Fig. 4 above, but the report must be able to repeat the full right-hand side of the hierarchy for each component.

Reports should be able to answer the questions asked by a reader in the more or less distant future. The only thing we know for sure about that reader is that we know nothing at all about what they will be looking for. This is an extremely important point about documentation. If we have fooled ourselves into assuming the future reader wants the information that we or our client wants, we will be wrong most of the time. In ten or a hundred years from now, a reader of our report may be looking specifically for the conservation materials we used, or our interpretation of past alterations, or the condition before our treatment, or what precisely we did and where we did it, or information about one of the components, or for our technical analysis of the original materials.

As much as everyone enjoys an engaging story in prose, our future reader is probably most interested in finding specific information quickly. Our report needs to be arranged in a way that information of particular types can be found – more like a reference book or outline than a novel.

How might a report efficiently answer so many diverse questions? CDS-D uses icons to mark each information type so the reader can easily filter the report by eye for whatever kind of information he or she is looking for.

The CDS-D report opens with object identification at the beginning, and for large projects, an “executive summary” can be included. The Phase section of this particular report shows that we are including an Examination and Treatment Proposal as well as a Treatment phase, each phase with dates, and staffing. The list of components (visible at the bottom of the example page) serves as a table of contents for the report. Thus all information about each component is together in the report, and the component list tells where to find it.




 <b>SANDGLASS ASSOCIATES</b> <small>Conservators of Fine Arts and Cultural History 518 Piner Road, Chicago, Iowa 52545-555-123-4567</small>		<b>Conservation Report</b> <span style="float: right;">Page 1 of 7</span>	
		Report Date 6/4/2005 Object Number <b>1997-61</b> Project Number 2003-014	
			
<b>Object/Title</b> Art Nouveau Lamp (sample project - do not delete) Period Early 20th c. <b>Attribution</b> Ferrand (attr.) Origin Paris <b>Owner</b> New Orleans Light Museum <b>Project Description</b> The lamp is being considered for exhibit. The curator asked for a condition assessment, and treatment in time for a 2006 exhibit. <b>Condition (Before Trmt)</b> The lamp has some flaking paint and dust, but it is generally intact. There has been replacement of electrical components, but may have original bulbs. <b>Project Intent</b> Clean and stabilize the lamp and improve its appearance for exhibit. Some signs of age are permissible. The lamp does not need to be operable. <b>Project Summary</b> This is an interim report of a sample project, as it might look during treatment and before completion. Some condition issues are shown with a proposed treatment but without an accompanying record of final treatment.			
<b>Project Phases</b> <b>Examination and Treatment Proposal</b> Begun 1/15/2003 Completed 1/17/2003 Phase # 1 Notes The examination and proposal preparation took place in the lab and required 2 hours to complete. Louise Smith, Project Conservator <b>Treatment</b> Begun 5/3/2004 Phase # 2 Notes The treatment is being conducted in the objects lab. It is to be completed by August, 2004. Louise Smith, Project Conservator Geoffrey Jones, Conservation Technician			
<b>Component List / Report Index</b> - Overall Lamp 1 - Human Figure 2 - Flowers 2.1 - Stems 2.2 - Petals 2.3 - Rose Lightbulbs 3 - Base 4 - Other Electrical Parts			
<b>Overall Lamp</b>			
<b>Description</b> The lamp is of a mass-produced type consisting of sheet, cast and tubular metals,			

Figure 8. The opening page of the comprehensive report.

Component 3 is the “base” of the object reported in the example (Fig. 9). Most of the component-level building blocks are found in this example, though components rarely have so many of report elements. The gray bar marks the beginning of the component, and it is always followed by any description of the component. This description includes two linked photos. The Analysis and Past Intervention records also relate to the description of the component, so they are next.

Conservation Report		Art Nouveau Lamp: Early 20th c.; Project No. 2003-014; Object No. 1997-01 Page 4 of 6	
3	Base		
Description	The base retains original decoration and is in generally good condition.		
Materials	Linden wood		
Coatings	The base is painted with faux tortoise shell, consisting of red spots on a red-black background.		
Construction	Turned with a recess to allow room for the screw and nut that hold the lamp together.		
	DSCN9018.JPG Painted wood base overall. Note faux tortoise-shell paint.		
	DSCN9112.JPG Underside of base showing hardware for assembly. Note even striations of lathe cutter indicating automated turning. Also note stray red and dark paint. Two slight checks related to the plaque nail holes are visible in the upper right.		
Analysis	Microscopic Wood Identification		
Analyst	GFJ	Completed 1/16/2003	
Objective	To identify the species of the wood to add to the catalog information.		
Description	A ca. 4 square mm shaving taken from the underside of the base revealed a transverse view for examination.		
Sample/Loc.	Near the outside edge, proper left rear quadrant of the base bottom.		
Method	Only a transverse sample was examined.		
Results	Wood diffuse-porous. Average tangential vessel diameter 80 µm. Vessels in multiples. Average number of vessels/mm <sup>2</sup> 100. Fibres of medium wall thickness; pits common and distinctly bordered, non-septate. Axial parenchyma banded; fine, typically two cells wide. Axial parenchyma apotracheal; diffuse and diffuse-in-aggregates. Axial parenchyma as strands. Average number of cells per axial parenchyma strand 4.		
Interpretation	The wood is Linden (Tilia sp)		
Past Intervention	exterior surfaces of base		
Attribution	ca. 1960s restoration		
Interpretation	Several repairs were made to the painted surface of the base.		
Evidence	Surface anomalies appear to be the result of in-painting.		
Condition	losses/missing parts	UNSTABLE	
Location	Side of base near bottom		
Notes	A small plaque has become separated from the base and the nails lost. Witness marks and two nail holes show its correct position; the plaque is inscribed "Pecheur."		
	DSCN9018.JPG Painted wood base. Note two nail holes marking location of lost plaque.		
Proposed Treatment	Assignment GFJ		
Cons. Materials	Paraloid® B-72		
Notes	Re-attach plaque using new escutcheon nails. To avoid stressing the splits at the old nail holes, use undersize escutcheon pins and secure them with B-72.		
Treated as Proposed			
Completed	6/12/2004		
4	Other Electrical Parts		
Description	The white grommet where the wire emerges from the back of the lamp is of an unidentified organic, probably animal material. It has irregular darkened pores similar		

→ Component (tinted)

→ Component Description

→ Photos (2 records)

→ Analysis record

→ Past Intervention Record

→ Condition Record

→ Action Records

(2 are shown, including Proposed Treatment & Treatment)

Figure 9. A page from the comprehensive report, showing information organized under and about one of the components.

A Condition record with a linked photograph follows. Then there are two actions associated with the condition record: a proposed treatment, and another as the final treatment. Future readers can easily scan for particular types of information by looking for the associated icons (Fig. 10).






Shaded Component Name	
	Past Interventions
	Condition Issues
	Action Records
	Analysis
	Graphic links

Figure 10. Icons used in the report to flag different types of information, including the shaded bar for marking the beginning of the next component.

Conservation Report		Art Nouveau Lamp: Early 20th c.: Project No. 2003-014: Object No. 1997-61 Page 6 of 7	
Materials	Mineral Spirits	(Continued from previous page)	
Step 5	Coat		
Notes	Two coats.		
Materials	Incralac		
Step 6	Waxing		
Notes	Warm surfaces with a hot air gun and apply one coat of Microcrystalline wax blend.		
Materials	Microcrystalline wax blend		
<b>Conservation Materials Cited in this Report</b>			
<ul style="list-style-type: none"> <li>Incralac, Formulated by the International Copper Research Association for use on copper alloys., Supplier: Available from Conservator's Emporium, 100 Standing Rock Circle, Reno, NV 89511</li> <li>Microcrystalline wax blend, This blend gives a slightly more durable final surface than Renaissance wax., Supplier: WAO5 microcrystalline wax is available from Conservation Resources International, LLC, 8000-H Forbes Place, Springfield, VA 22151. Polywax 2000 is available from Conservation Support Systems, 924 West Pedregosa St., Santa Barbara, CA 93101.</li> <li>Mineral Spirits, A hydrocarbon petroleum distillate. Sold as Stoddard solvent by Fisher Scientific., Supplier: Fisher Scientific, Pittsburgh, PA 15205.</li> <li>Orvus Paste, Synthetic detergent with a neutral pH., Supplier: Conservation Support Systems, 924 West Pedregosa St., Santa Barbara, CA 93101.</li> <li>Paraloid® B-72, ethyl methacrylate (70%) and methyl acrylate (30%) copolymer. It is soluble in toluene, xylene, acetone, carbon tetrachloride, MEK., Supplier: Rohm &amp; Haas, Philadelphia, PA 19105.</li> <li>Pre-Lim Surface Cleaner, A mildly abrasive paste of calcium carbonate in a buffered emulsion of petroleum distillates and water., Supplier: Picreator Enterprises Ltd., 44 Park View Garden, Hendon, London, NW4 2PN, England.</li> </ul>			
<b>Report Attachments</b>			
<a href="#">Item 1. Wood ID Worksheet</a> Attached Report on the Base wood identification.			
<b>Recommendations for Preventive Conservation</b>			
<b>Environmental Conditions for Exhibit</b>			
Overall Lamp - Light: 25 footcandles; Relative Humidity: 40-60%			
<b>Special Handling Instructions</b>			
Overall Lamp - Minimize handling and use plastic gloves. Be careful of possible flaking of paint on white metal figure. Note hazard of falling over because of the relatively large size of the lamp and the small base.			
Light Bulbs - The color coatings are vulnerable to abrasion and should be handled carefully to avoid further losses.			
<b>Signatures</b>		<b>Date</b>	
Project Conservator			
Curator			

} Page Header  
 } Standard Procedures  
 (detail section)  
 } Conservation Materials  
 cited in report  
 } Report Attachments  
 } Preventive Conservation  
 Recommendations  
 } Signatures

Figure 11. The report appendix.

The automatically-generated appendix of the report (Fig. 11) details any “standard procedures” you cited in the project. Just the end of one standard procedure appears in the example. The conservation materials you cited in the report are then automatically listed along with the information about each that you had entered in setup. The appendix also includes a list of report attachments, preventive conservation recommendations, and boxes for approval signatures.

This software is designed for conservation documentation does not attempt to serve as a collections management system (CMS). However, CDS-D integrates well with any CMS database that can accommodate hyperlinks. By outputting CDS-D reports as PDF files, the reports can be linked to the CMS for access from within the CMS. TMS, the popular collections database by Gallery Systems, for example, allows such links. A curator or conservator thus can look up an object in the collections management system, and click on a link to open a full conservation report in Adobe Reader.

Can old conservation reports be retrofitted into CDS-D? In theory, this should be quite easy, but in practice, such an exercise is made more difficult because of the coherence problem: As explained above, old reports rarely have good linkage between specific condition problems and their actual treatment proposals and treatments. One or the other half of the condition-action sequence is often missing or insufficiently related.

In summary, CDS-Documentation uses computer technology to greatly improve the accuracy and utility of our conservation records through database technology. It can handle conservation projects from the very smallest and simplest to the largest and most complex, using a few forms as building blocks. It automates many documentation tasks to save recording time, and it systematizes not only our documentation, but our perceptions. It helps us complete with consistency the full sequence of observation, judgment, and intervention—component by component.

## **Acknowledgements**

The author thanks James F. Judson of Conservation Data Systems, LLC for making this concept a reality, and for publishing it for other’s use. Aspects of the CDS-D data structure are based on original work by Nicholas Waanders. Many of the program’s features are the result of suggestions from users, some of whom are on the staff of the Department of Conservation, Colonial Williamsburg Foundation.

## **Endnotes**

1. CDS-Documentation is available from Conservation Data Systems, 3000 Ashley Way, Williamsburg, VA, 23185, ([info@ConservationDataSystems.com](mailto:info@ConservationDataSystems.com), [www.ConservationDataSystems.com](http://www.ConservationDataSystems.com)).

2. The AIC Guidelines for Practice is published online at <http://aic.stanford.edu/about/coredocs/coe/> (accessed on 7-10-2006).

3. The presentation was entitled “Houston, We Have a Solution: The Assessment, Documentation, and Treatment of the Saturn V Rocket Located at the Johnson Space Center” by Joe Sembrat, Patty Miller, John Pursley, and Jee Skavdahl, and presented by Joe Sembrat.

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## **DATABASES, DIGITAL IMAGES, VIDEO AND MORE: DOCUMENTATION FOR THE NMAI COLLECTIONS MOVE**

Emily Kaplan and Rachael Perkins Arenstein

### **Abstract**

Extensive documentation was used as a way to facilitate and speed a five-year project to move the National Museum of the American Indian's collection of more than 800,000 Native American objects from New York to Suitland, Maryland. Almost all of the Move Project staff members were contract employees whose term ended with the completion of the project. This loss of institutional memory necessitated that documentation be considered a priority. Conservators used a variety of technologies, some old and some new, to document work on objects and to document move-related activities.

This paper describes the methods used to document conservation treatment and move-related activities. Written documentation of treatments evolved from word-processor electronic text documents through several generations of stand-alone databases. Documentation of pest management treatments involved an additional set of databases that incorporated barcodes and scanners to increase speed and accuracy of data entry. Visual documentation of treatments and general move procedures changed over the course of the project from being primarily film based to relying heavily on video and digital imaging; by the end of the move, over 23,000 such digital images were produced. This mass of images would have been virtually useless without the implementation of a digital asset management system, a database that facilitated organization and allowed the association of data to ensure that the images are searchable and retain their context for future use.

The issues encountered in choosing appropriate documentation methods and the success of various strategies as technology changed is discussed.

### **Background: History of the National Museum of the American Indian**

To understand the complexities of documenting the National Museum of the American Indian (NMAI) Move Project, a review of the institution's history is helpful. George Gustav Heye (1874-1957) founded the Museum of the American Indian in New York City in 1916. Gathered during a 45-year period, his collection became the basis of the museum's collection of more than 800,000 objects from indigenous peoples throughout the Western Hemisphere.

The Museum of the American Indian/Heye Foundation opened at 155<sup>th</sup> Street and Broadway in Manhattan in 1922. In 1926, when Heye's extensive collecting overwhelmed the storage space in the new museum, a state-of-the-art storage facility, called the Research Branch (RB), was built in the Bronx to house the rest of the collection.

In 1989, the Smithsonian Board of Regents agreed to transfer the Museum of the American Indian Heye Collection to the Smithsonian Institution, renaming it the *National* Museum of the American Indian, thus creating the Smithsonian's 16<sup>th</sup> museum.

The agreement led to the creation of a third facility, the George Gustav Heye Center at the U.S. Custom House in lower Manhattan. When it opened to the public in 1994, this building replaced the outdated facility at 155<sup>th</sup> Street and Broadway.

The Cultural Resources Center (CRC) in Suitland, MD, was designed to provide long-term housing and care for the collections and offers Native communities and Native and non-Native researchers access to objects that are not on exhibit. This building opened in 1999, initiating the collections move project that was completed in the spring of 2004. The old Research Branch was sold to a private developer in late 2005. The final element is the NMAI Mall Museum, which opened September 21<sup>st</sup>, 2004 on the US National Mall in Washington D.C.

## **Introduction: Documentation**

The topic of documentation touches on many aspects of the Move Project. Documentation was used to facilitate and speed the five-year project to move this large and varied collection from New York to Suitland, MD. Several of the methods used to document the status and location of each object through the move process, including labels, notes and barcodes, have been previously presented or published (Kaplan et al. in press; Arenstein et al. 2004; National Museum of the American Indian 2004; Williamson et al. 2001).

Along with many other institutions, the Conservation Department at NMAI now relies heavily on digital imaging and has undergone a transition from individual electronic files and hard copies to a database or databases for object condition and treatment documentation. Rather than focusing on these methods of documenting conservation treatments of individual objects, this paper will examine the documentation of the move process itself.

There were two main reasons for a concerted effort to document the general work on the Move Project. First, documenting the move procedures and progress was important internally – to train staff during the life of the project, and from an institutional archival perspective. Nearly all of the Move Project staff members were contract appointees whose term would end with the completion of the project. This loss of institutional memory necessitated that documentation of the project be considered a high priority. Second, NMAI staff felt a responsibility to present information in hopes that others in the field might learn from the successes and mistakes of the project. Therefore, extensive documentation for conferences, presentations, and publications was produced.

The move project was halfway complete when it became clear that the documentation was overwhelming in some areas and inadequate or, at least not in a coherent form, in others. For example, at the midpoint of the project the New York end had accumulated over 1,500 digital images that recorded various aspects of daily move activities, as well as special events such as the move of totem poles. At the CRC in Maryland, there were more than 500 additional images of unloading trucks, unpacking boxes and crates, constructing storage supports, shelving objects,



and installing compactor storage unit hardware. With over two years left on the move project, it was recognized that the ability to manage this documentation would quickly spiral out of control.

Staff realized that more concrete guidelines needed to be devised for written and digital documentation of general move activities and that it was necessary to plan for successful implementation. Numerous discussions were held to determine documentation goals, assign staff and equipment resources and plan for the product.

A decision was made to focus on two areas: first, documenting the procedures and methods of the Move Project itself and second, documenting the Research Branch facility, the last remaining part of the original Museum of the American Indian facility as established by the founder George Gustav Heye. A series of documentation projects that included a text based move procedures and packing manual, digital photography, videography and print photography were implemented.

### **Written documentation: Move Manual**

The NMAI Move Procedure Manual, currently a text-based document in PDF format, grew out of the various written procedures guidelines and illustrative images generated by both the New York and Maryland ends of the move. The sections are hyper-linked from the table of contents allowing quick and easy access to each section. The manual was intended to give both an overview of the fundamental policies and strategies for the move as well as some detailed how-to instruction. It includes numerous appendices consisting of forms, checklists, and guidelines that were produced during the move. These procedures evolved over the course of the project, and some of those included in the manual changed after the document was produced.

The document was originally intended as an in-house training manual for immediate use, to be updated continually, as well as a document for the archives and for future planning. At some point along the way, the manual began to be thought of as a potentially useful document for colleagues in the museum field. Another impetus for compiling and editing the manual, besides the impending end of the move project, appeared when the New York move team managers began preparing for presentations at a 2003 AAM workshop on moving collections. A packing manual was compiled and the general procedures manual finalized as best as possible. The fifty participants at this workshop each received a binder with a printed copy of the manual, a CD containing the move manual as a PDF and the packing manual as a PowerPoint show, and a DVD with a video entitled "Follow the Object" which will be discussed below.

### **Lessons Learned from the Procedures Manual**

The Move Procedures and Packing Manuals were time consuming to produce and difficult to finalize, and the definition of who the end-users might be shifted over time as priorities changed. Determining a responsible, ethical, and useful way to disseminate this material has been a challenge, and staff and management are currently considering several options to distribute the manual in either hard copy or digital format. However, initial responses from colleagues who have received the manuals indicate that the manuals are useful. As many colleagues note, any

documentation at all about a move project provides a useful guide as there is a dearth of available information, published or otherwise, on moving collections.

Parts of the document did work well as an in-house training manual, particularly the packing section, and some of the forms and instructions that are now appendices. On the other hand, the document was not particularly useful for training staff on rehousing methods at the CRC. It would have been wonderful to be able to hand new staff a rehousing manual so they would know how to construct supports for moccasins, textiles, baskets, and ceramics, etc. However, despite ongoing attempts, hundreds of digital images, and hours spent processing them, rehousing techniques were constantly being refined throughout the life of the project, so any draft document inevitably became virtually obsolete by the time it was produced. With the move project now finished, work is being done to organize and disseminate examples of rehousing techniques to colleagues, primarily through digital images, PDF documents, and PowerPoint presentations.

### **Digital documentation: Photography**

Digital photography was the method most frequently used for documenting the overall move process. (Here, a distinction must be made between these “snapshot” move documentation images taken, often on the fly, by move project staff, and the high-resolution images, taken by NMAI Photography Department staff, of each object in New York before it was packed for the move. These object images, which are used for the museum’s collections database, for exhibit planning, research, repatriation, and sometimes publication, were managed separately and continue to be managed separately at the CRC.) Initially, the move documentation images were simply organized by re-naming them and filing them in folders grouped by year and subject using Microsoft Explorer. However, as the numbers of files increased into the thousands it became clear that staff were losing the ability to find these images and associate important data images with them.

Presentations on the topic of documentation in the general session of the 2005 annual meeting of the American Institute for Conservation served to underscore both the growing acceptance of digital imaging within the conservation field and accompanying concerns not only about storage and accessibility but also about managing digital images and accompanying metadata. By the time that meeting was held, Digital Asset Management systems (DAMs) were becoming commonplace. However, during the course of the move project, neither NMAI nor the Smithsonian had yet committed to a comprehensive DAM system. Nevertheless, given the finite nature of the move project in terms of time and staff, staff determined it necessary to implement such a system as quickly as possible. Move staff also needed to assure the NMAI Information Technology department that the choice would be cost effective and would allow the images and metadata to be rolled over to a future system.

There were several DAM programs on the market at the time, and staff selected Extensis Portfolio Server as most suited to the needs of the move project. This is a network version of Portfolio, a consumer product for managing graphic files that combines a thumbnail graphic image with metadata fields. Using these data fields, the user can associate text notes and other

information with the image, creating a searchable database. The network version can manage up to 300,000 images per catalog and accommodate multiple users. The cost, along with six user licenses, was about \$2,500. Using the server version of the platform allowed staff in New York and Maryland to work on the program together.

## **Organizing Digital Photography**

Extensis Portfolio is Portfolio does not modify the original image. It merely creates a mirror thumbnail to which associated data can be attached. Images can be viewed in three ways: as thumbnails, in list form, and by individual image. Portfolio has several places to input metadata, all of which is searchable. The program automatically generates keywords based on the file name and path, and there is a description field that allows free text.

For the purposes of this project, the program's "Custom Field" capability was most important because it allowed for the creation of some categories with pull down menus and others with free data entry. A committee was formed including conservation, archives, imaging and administration to determine what data would be essential to associate with the images, trying to balance the need for information with the need for speedy data entry and a consistent lexicon of standard metadata nomenclature. The following categories were included as custom fields in the Move Documentation Database:

- Photograph Location – i.e. RB, CRC
- Photographer Name
- Date
- Collection – Archaeology or Ethnology
- General Regional Provenience – e.g. Northwest Coast, Northeast Woodlands, Plains
- Catalogue number – if a specific object e.g. a totem pole was emphasized in the image
- Activities – i.e. packing, conservation, rehousing
- Archeology Provenience
- Ethnology Culture/ Tribe
- Subject(s) –staff names

For each of these categories the committee devised a drop menu of options. For the "Ethnology Culture/ Tribe" category, the entire culture list of more than 100 names was imported from the museum's registration database. Some of the fields - such as "subject" - allow for multiple entries, so the user may add a number of different names. Using these custom fields required the person doing data entry to use only standardized spelling and naming conventions.

The program allows for Boolean searches on any number of fields, allowing search criteria to be easily refined. The images can also be sorted according to any of the fields. As most of the staff members who created these images are no longer at NMAI, maintaining searching viability for long-term end users was essential.

While the museum would not have purchased a DAM system solely for use in conservation, conservation staff at the RB in New York soon realized that there were numerous potential applications for a stand-alone Portfolio database in the conservation lab. In preparation for

transport, an average of 6,000 objects each week were examined, cleaned, and stabilized if necessary. Although less than 1% of the collection was treated, this process still generated massive amounts of documentation as required by the conservator's code of ethics.

Retrieving images, however, was always problematic unless one remembered the object catalogue number. This problem was solved by Portfolio. Custom fields were established with basic catalogue information as well as key words for materials, condition and deterioration issues. This made it easy to find images of objects as illustrations for reports and presentations -- for example, objects that showed particular kinds of deterioration or damage, such as glass disease or pest activity.

Long before the end of the move, Extensis Portfolio proved to be an invaluable resource in preserving memories of the move project. By the end of the move, the database consisted of over 10,000 move images and 3,500 conservation images that remained accessible allowing easy searches to pick images for PowerPoint presentations. The Smithsonian is in the process of adopting a comprehensive Data Asset Management System. As the information stored in Portfolio can be easily exported as tab-delimited files with each of the metadata categories, this information should be incorporated into any future database.

### **Video documentation**

Although the bulk of the move documentation was accomplished with digital imaging, certain aspects of the move were best documented with video. Video was used to document lectures, blessing ceremonies, conservation and packing techniques, and the move of some of the larger objects such as totem poles, as well as day-to-day move activities. In the final months of the move, an oral history project was also begun to document memories of present and past employees of the move.

Recent advances in digital video and editing software packages like Final Cut Pro allow almost anyone to be a film producer. This work was accomplished in New York with in-house staff using equipment that is relatively accessible and easy to learn. Some video projects were shown at conferences or burned onto DVDs for museum trustees. The most important project was a high quality video DVD, approximately 30 minutes long, that captures a general overview of the move as well as numerous specialized presentations on specific aspects of the project. The overview explains and documents the standard move procedures by following a single object through registration, conservation, imaging, packing, crating, shipping, unpacking and shelving. Along with the Move Procedure Manual, the DVD has been distributed to interested museum professionals and has garnered positive feedback. Discussions are still on going as to how this might be disseminated to a wider museum audience.

Even if it had not have been possible to produce any final products, the time invested in videography was worthwhile. In the end, the priority was to capture the raw footage, which can always be edited or used as needed down the road.

## **Documenting the facilities: Print photography**

About three-quarters of the way through the project, large format photography began to be used to document the facilities as they changed over the course of the project. The storage vaults at the RB, some of which were empty or half-empty at that point, as well as some groups of objects and areas of the building were recorded using 4x5" format film. Storage areas at the Cultural Resources Center were photographed as they were filled. The resulting beautiful prints have already been used to decorate the walls of the CRC, some are to be accessioned into the collection and there are plans to use them for SI and NMAI publications. The prints and negatives from this project were not so extensive that they were not easily managed, and they fell under NMAI's Photography Department guidelines for storage and archiving.

## **Panorama Photography**

Digital panorama photography was used to add a bit of life to the documentation of the storage vaults. The goal was to capture the conditions in which the objects were stored and show how crowded the interior spaces were. Since the RB facility was to be sold at the end of the move it was important to record the building as it was originally envisioned and established by George Heye. QuickTime panorama photography, the same technology that is often used on hotel web sites to give a "three-dimensional" view of rooms, was used. While this requires a bit of specialized equipment to create, this too was done in-house. The images allow for a 360-degree rotation, moving up and down depending on the scale of the original digital image, and zooming into a particular area to see a detail.

## **Conclusions**

A review of lessons learned from this project generated some general tips that may help guide the development of a documentation program, no matter what the specifics of the project. These suggestions include: establish guidelines on what events or processes require documentation; determine the audience for the documentation; determine what format will best convey the information to that audience; cull and organize digital images and re-evaluate as the project progresses; be selective as more is not always better; make documentation consistent so that it is useful in the future. An institution can benefit from having good project-based documentation in numerous ways: training/education; self-evaluation of workflow, goals, and management; improved productivity, improved accountability, publicity, fundraising and outreach; and planning future projects. Finally, perhaps most important of all, comprehensive project-based documentation can, at the very least, make sincere attempt at capturing institutional memory before it is lost.

## **Acknowledgements**

The authors would like to thank the staff of the NMAI Move Project with particular acknowledgment and gratitude to Leslie Williamson and Angela McGrew.

## Suppliers

The Portfolio digital asset management system is a product of Extensis <http://www.extensis.com/>

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## **DOCUMENTING THE DOCUMENTERS: THE CONSERVATION SURVEY OF THE AKELEY HALL OF AFRICAN MAMMALS**

Judith Levinson and Sari Uricheck

### **Abstract**

In 2002-3 the American Museum of Natural History undertook a conservation survey project to ascertain the condition of the 28 large dioramas and a group of eight mounted elephants in the Akeley Hall of African Mammals. The hall is the physical and iconic centerpiece of the American Museum. It is characterized by innovations in the production of museum exhibits, taxidermy and education that were largely made by Carl Akeley, after whom the hall is named. Results of the survey indicated that all specimens, wall paintings and foreground materials were very desiccated, largely the result of uncontrolled environmental conditions, especially high heat and UV illumination from the lighting. Other condition issues of the diorama specimens were caused by prior restoration. The mounted elephants were found to be in the worst condition due to being exhibited in the open. Recommendations for future renovation of the hall included environmental modification: replacing old light fixtures with more modern lighting technology and adding humidification to the HVAC system, in addition to treatment of the elephants.

### **1. Introduction**

The Akeley Hall of African Mammals is the centerpiece of the American Museum of Natural History, both literally and as an icon. It is located just beyond the grand entrance of the museum at the Roosevelt Rotunda and is comprised of two floors of exhibition space, which consists of 28 large dioramas and a central open platform with 8 mounted elephants (Fig. 1).



Figure 1. View of Akeley Hall of African Mammals.

Over 60 species of mammals and 15 species of birds are presented in numerous African habitats, including wetlands, deserts, mountains and rain forests from specific sites ranging from the volcano of Mt. Karisimbi to the Kalihari Desert. Although one of the oldest displays in the museum, it is still considered among its most important in terms of exhibition technique, museum education, artistic production and audience popularity. The purpose of the conservation survey was to investigate the hall's current condition with regard to the need for renovation to assure preservation for the future.

## 2. History of the Akeley Hall

The Akeley Hall is named in honor of its creator, Carl Akeley, inveterate naturalist, artist, taxidermist and inventor. Carl Akeley was a man ahead of his time. From humble beginnings as a lab preparator for Ward's Natural Science, Carl Akeley became the driving force behind one of the museum world's most ambitious and impressive exhibit halls. In describing his life-long dream, Akeley wrote:

The African Hall which I proposed to the AMNH is meant to record fast disappearing phenomena and put in permanent and artistic form a complete hall of exhibits of animals in the best manner known to museum technique...(it would) preserve a unique record of Africa but also it would establish a unique and new record in taxidermy and the associated arts. (Akeley, C.E. 1920, 194)

Akeley led several expeditions to Africa between the years 1905-26. As with other scientific expeditions of the day, he brought painters with him to record the landscapes and included teams of artists and scientists to collect samples and data on flora and fauna (Fig. 2).



Figure 2. Photograph taken by Carl Akeley of painters documenting landscape for Klipspringer Diorama. Courtesy of AMNH Library.





Figure 3. Completed Klipspringer Diorama in Akeley Hall.

Akeley invented new camera equipment, for which he holds numerous patents, to accurately record the natural phenomena he witnessed and which he was convinced were rapidly disappearing. With a comprehensive vision of the final product, Akeley seemed to plan every detail of hall construction from structural dimensions, electrical layouts, exact measurements of canvas backgrounds and environmental specifications for exhibit preservation – all with the audience’s experience in mind (Fig. 3).

The museum’s board of directors approved Akeley’s African Hall proposal in 1912 and work began in 1914. In a publication from 1936, the author states that

“In no other museum have whole halls been planned and carried out as a unit. Even while carpenters, iron workers, and masons are constructing the cases, an artist is at work painting a background. Every available preparator is at work on some part of a group. (Clark 1936; 80)

Production continued slowly through the Depression, and the death of Akeley himself in 1926. The first stage of the Hall opened in 1936. By 1942 the entire hall was open, with few compromises to Akeley’s original plan, as specified in his earliest descriptions and letters in the museum archives. An army of artists and craftsmen, including the highly regarded naturalist artists William R. Leigh, James Clark and James Perry Wilson, had contributed their efforts toward realizing Akeley’s vision (Fig. 4).

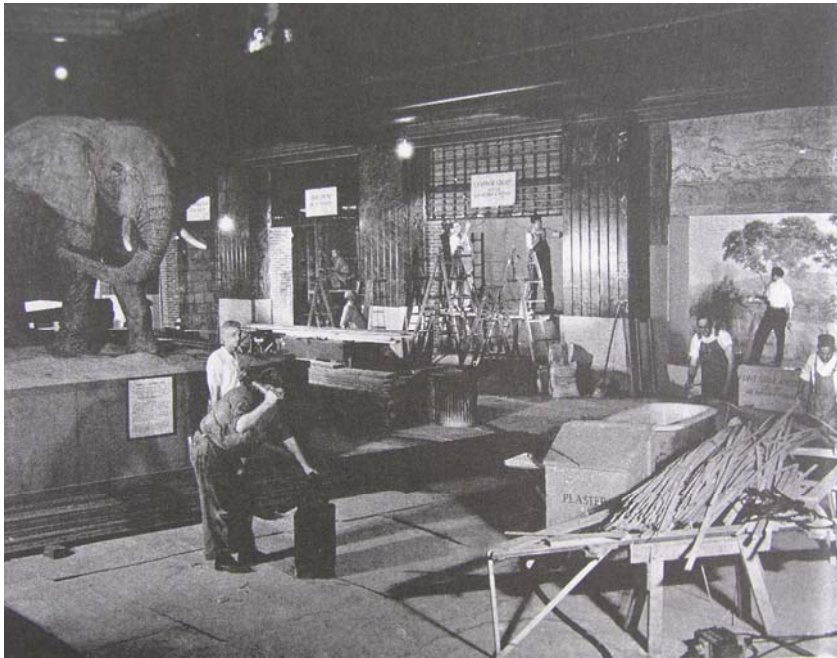


Figure 4. Work in process: construction in Akeley Hall. Courtesy of AMNH Library.

### 3. Construction and technical aspects of the dioramas

The diorama enclosure designed by Akeley was a concave enclosure constructed from vertical angle iron beams and heavy wire mesh as support, built up with layers of plaster and then canvas with lead white primer to the surface. The front face of the diorama consists of a large glass panel that is tilted slightly so the viewer sees no reflection. A light box with fixtures for interior illumination is located above the concave enclosure. Access to the light attic is achieved via catwalks into them on the first floor of the hall and by removing decorative bronze panels above the glass fronts on the second floor, which has a lower ceiling height (Fig. 5).

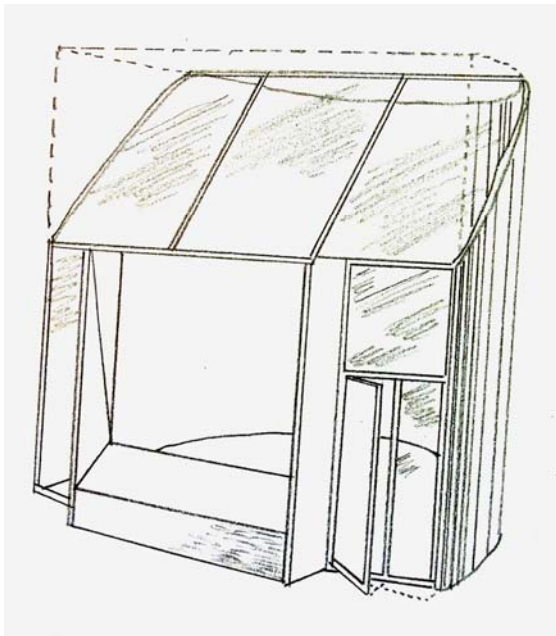


Figure 5. Illustration of Akeley diorama design. Drawing by J. Levinson, after Jacques 1931: 10, Fig. C.

The diorama is a relatively well-sealed concave shell whose shape is the secret of its successful illusion. It is an enveloping panorama with no seams or corners; the three dimensional elements blend smoothly into the 2-dimensional scene (Fig. 6).



Figure 6. An example of blending foreground elements into the painted background, from Upper Nile Region Diorama.

The painted backgrounds were meticulously distorted by arithmetic convention, so as to play with the viewer's perspective, drawing the observer into the scene. Using field notes, sketches and models, artists including Robert Perry Wilson and James Clark, made innovations to the process of diorama background painting of the day that lend these exhibits their realistic, atmospheric genius (Fig. 7).



Figure 7. Photograph of James Clark with model for Lion Diorama. Courtesy of AMNH Library.

#### 4. Taxidermy and foreground techniques

While the painted backgrounds were innovative, the taxidermy of the specimens was the most revolutionary aspect of the Akeley diorama ensemble. Building on his early experience, Carl Akeley developed a new taxidermy process, changing it from a crude process to a precise sculptural technique. The goal of his method was to record and recreate the animal form with the greatest and most dramatic accuracy.

As a young man, Akeley gained experience at Ward's Natural Science Establishment where, among other projects, he helped prepare the Barnum Circus' original 'Jumbo' exhibit. This experience led him to question the accepted mounting procedures of the nineteenth century. Instead of the standard taxidermy method, which to him created lifeless forms by "filling a raw skin with greasy bones of the legs and skull and stuffing the body out with straw, excelsior, old rags, and the like" (Akeley, C.E. 1920, 188), Akeley created an accurately modeled animal body and tightly fit the tanned skins over it. The over-riding significance of Akeley's innovations to the taxidermy process is that he developed an art form objective and accurate enough to be used in scientific presentations. (Quinn 2005)

For mounting specimens with fur using the Akeley method, an exact replica of the animal, based on measurements and casts made in the field, is modeled in clay (Fig. 8). A plaster mold is then made from the clay model and a thin paper mache replica is formed inside the mold. The paper mache figure is supported on its interior with burlap, wire mesh and wood ribs and then the tanned skin is applied to the outside of the paper mache replica (Fig. 9). This hollow, light-weight mount attains a life-like appearance that results from the high degree of accuracy transmitted throughout the entire process.

The process Akeley developed for elephants, as well as for rhinoceros and hippopotamus, was slightly different and could only be used on hairless animals. The tanned, thinned elephant skin was modeled and shaped onto the accurate, sculpted clay model whose dimensions, again, were based on measurements and casts made in the field.

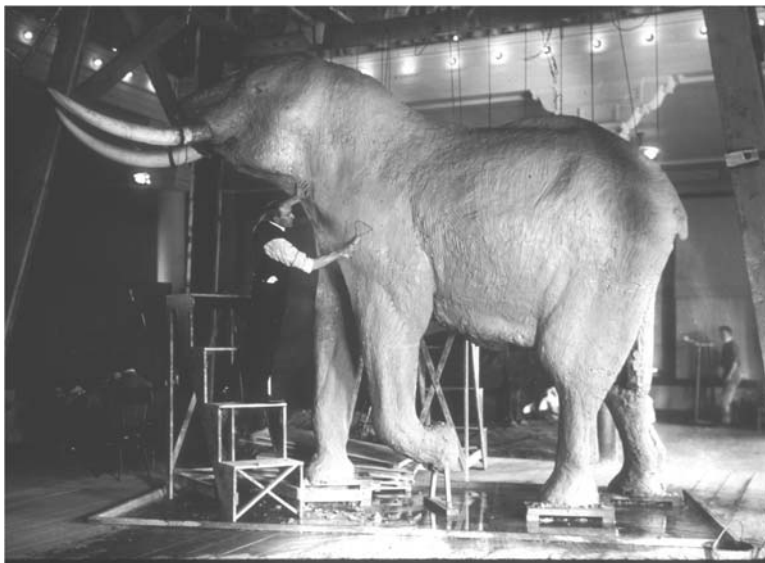


Figure 8. Photograph of Carl Akeley sculpting elephant model in clay. Courtesy of AMNH Library.





Figure 9. Image of pulling elephant skin over sculpted model, taken from film of mounting Asian elephant. Courtesy of AMNH Library.

A plaster jacket was applied directly onto the elephant's skin (this process can only be used on hairless specimens). After the plaster mold had dried, it was split in half laterally and the clay was removed from the inside. The skin was reinforced on the interior with layers of wire mesh, hardware cloth, mache mixture and wood. The outer jacket was then scraped off with wire brushes and the resulting thin but strong halves of the elephant's body, as well as the head (which had been prepared in the same manner), were joined together from the inside around a new wood and steel armature (Quinn 2005).

While known for the "Akeley method" of taxidermy, Carl Akeley's vision was to bring the same high level of innovation to the environmental aspects of the diorama. To accomplish this, artists accompanied the field expeditions to collect floral and faunal specimens. They made corresponding sketches and models of the landscapes they encountered. Small-scale dioramas made on site are recorded in photographs of expeditions. Their three-dimensional elements are made from wood, wire and plaster, the same core components as were ultimately used in the Akeley Hall dioramas. The most ground-breaking aspect of this approach was the combination of natural and fabricated elements and the high degree of realism achieved (Fig. 10).

The technology of creating imitation plants was just being mastered during the production of the Akeley Hall. Natural collected elements from the field, such as grasses and moss preserved by soaking in glycerine, soil, and tree branches, were combined with fabricated specimens using combinations of painted cast wax, paper, plaster, paper mache and metal sheeting. Molds of leaves, flowers, rocks, bark and tree trunks taken on site were utilized to create the fabricated foreground materials. In situ drawings and paintings helped to insure color accuracy (Fig. 11).



Figure 10. Image of deck construction of foreground in Upper Nile Region Diorama.



Figure 11. Photograph of a step in leaf fabrication process. Courtesy of AMNH Library.

## 5. The survey process

The broad nature of the materials in the dioramas and the complex environments within the hall demanded various types of expertise to evaluate them. Given the magnitude of this conservation survey project in terms of its goals – to be as comprehensive and holistic as possible – and the large number of participants, an efficient methodology and clear organization were required. Procedurally, standard art conservation survey protocols were applied to assess exhibits previously viewed as expendable educational or exhibit materials. The numerous dioramas and specimens and the complex nature of this particular exhibit hall makes exhaustive reporting of all the elements of the survey beyond the scope of this paper. It should be read as an outline of what were considered the most important elements that ought to be included in a survey of this type.

The goal of the survey was to examine the condition of all the specimens, background paintings and foreground materials to gain as full an understanding of the environment within the dioramas and the hall as possible, given time and financial limitations. The dioramas had never been systematically assessed, but there were at least two previous cleaning and restoration campaigns. These took place in the 1960's and the first half of the 1980's. Documentation of prior condition and the work undertaken was not carried out for either effort.

The most recent conservation survey, funded by the Getty Grant Office, took place over the course of 18 months in 2002-3. An initial period was dedicated to preliminary research and planning, which was followed by three phases for active surveying. A fourth phase of several months, consisting of performing additional scientific analyses, gathering of cost assessments and planning for future implementation, was added to the project at the end.

The research and planning phase involved searching through the museum's archives for background information about materials, methods, personnel and landmark dates. Photographs, films, personal correspondence of Akeley and other museum personnel regarding trips, finances, aesthetic goals, etc. were gleaned from these sources, and lastly, resources were focused on planning and executing the survey.

Before embarking on the enormous task of surveying every specimen and piece of foreground material, a system for labeling and recording was developed, which included devising detailed condition forms and making diagrams of cases with specimen identification systems. A system for labeling and recording was developed for each diorama and this specimen identification system was integrated into a central database (Fig. 12).

A FileMaker Pro/Access convertible database was designed to collect all the data regarding the foreground materials. Tick mark condition forms simplified data collection and allowed for additional non-conservation staff to contribute/aid in the survey (Fig. 13). The relational aspect of the database allowed for the background and archival information to be merged with the generated condition notes. The outside consultants came with their own forms for collecting information, although ideally, their data would have been merged into the central database file.

The survey process had to be accomplished in stages in order to schedule around a number of special events for which the hall had been long committed. Barriers were built in front of runs of contiguous dioramas to provide a secure work environment and behind which survey materials could be stored. The staggered scheduling ensured that no more than 1/4 of the hall was closed to the public at any one time.

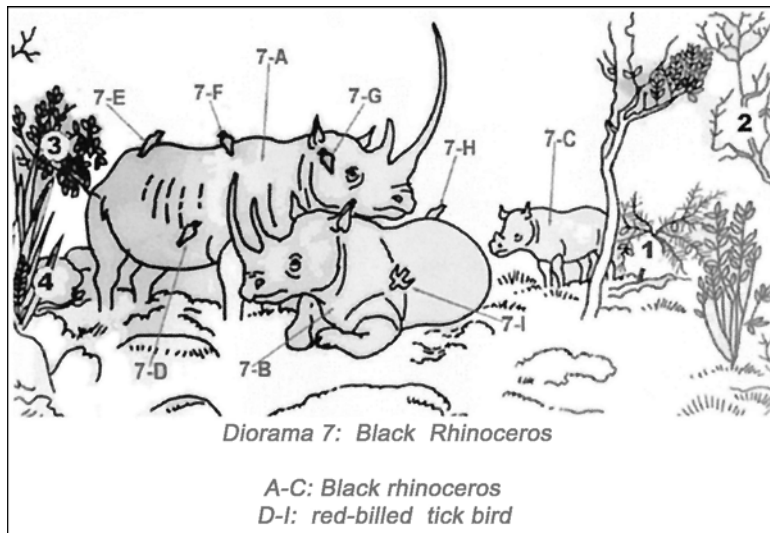


Figure 12. Annotated drawing with species and plant identification system from Black Rhinoceros Diorama.

diorama leopard/bush pigs

foreground elements

<input type="checkbox"/> ground	<input checked="" type="checkbox"/> tree	<input type="checkbox"/> fruit	<input checked="" type="checkbox"/> sticks	<input type="checkbox"/> roots	<input checked="" type="checkbox"/> bark
<input type="checkbox"/> rock	<input checked="" type="checkbox"/> shrub	<input type="checkbox"/> water	<input checked="" type="checkbox"/> vines	<input type="checkbox"/> flower	<input type="checkbox"/> misc. props
<input checked="" type="checkbox"/> dirt	<input checked="" type="checkbox"/> grass	<input type="checkbox"/> termite hill	<input checked="" type="checkbox"/> moss	<input type="checkbox"/> succulent (aloe, cactus)	<input type="checkbox"/> Other... LOG - DRIED LEAVES (NATURAL)

materials

<input type="checkbox"/> real plant matter	<input checked="" type="checkbox"/> painted surface	<input checked="" type="checkbox"/> yucca	<input checked="" type="checkbox"/> wire	<input type="checkbox"/> cellulose acetate	<input type="checkbox"/> Other...
<input checked="" type="checkbox"/> real dirt	<input checked="" type="checkbox"/> plaster	<input checked="" type="checkbox"/> paper	<input checked="" type="checkbox"/> cotton/fiber	<input type="checkbox"/> cast resin	

flaking bugs analysis

#	common name	description/manufacture	condition
1	Lion's ear (orange flowers or plant)	BARK - NATURAL BRANCHES - STEMS - FABRICATED - LEAVES - GREEN? WAX/PAPER? - FLOWERS	GOOD ✓ 1- LEAF HAS OLIVE POINT (BARK - FABRICATED) 1- LEAF TIP REMAINS BUSHY (WAX - PAPER) 1- LEAF - WHITE RESIDUE (PAPER) (LEAF TIP)
2	gladiola	PAINTED PAPER FLOWERS - STEMS - PAINTED WAX/LEAVES? - LEAVES - PAINTED PAPER?	GOOD - MINOR PAINT PEELING
3	torch flower (red-hot poker)	PAINT WAX w/ PAPER BUSH - ART. LEAVES w/ PAPER WAX - STEMS - PAINTED WOODS	SOME IN DARK AND 2 DIMENSIONAL (PAINTED PAPER) - LEAVES - PAINTED WAX - GOOD CONDITION - WAX - 1- BARK FLOWERS HAS MINOR TOP - LEAVES - PAINTED
4	myrtle	DRIED NATURAL BRANCHES - TWIGS & STEMS (PAINTED)	SOME SMALL LEAVES SEEM TO BE DRY NATURAL (BROWN) OTHERS (GREEN) COULD BE PAINTED ON WAX (PAPER) ON COMBINATION - GOOD COND. - SOME AREAS - SPARSE
5	PAINTED PAPER (WAX) LEAVES vine on tree	OTHER VINES: DRIED NATURAL - PAINTING VINES WAX - LEAVES w/ WAX & WAXED PAPER	VERY DRY, DISCOLORED - GOOD ✓ * - 1 SMALL VINE ON RT - PAPER - VISIBLE FROM
6	fern (color green - not waxed) dead known branches look bad	WIRE BRANCHES - PAINTED WIRE / PAPER LEAVES	GOOD ✓ - SOME LEAVES BENDING OUT OF POSITION - WIRE - SOME WHITE RESIDUE IN UPPER PART SEEN - LEAVES are droopy - some are glossy
7	mushrooms (on left)	CAST WAX? and painted on surface	GOOD - attachment to bark is discolored and glossy (glue)
8	log (in foreground)	PLASTER/MAPLE? WIRE MESH w/ NATURAL BARK/WOOD - PAINTED NATURAL WOOD COVER - PAINTED WAX? PAPER LEAVES - GOOD ✓	GOOD COND. - BARK SEEMS STABLE
9	plant w/ green and orange leaves & groups	COTTON/WAX/PAPER? LEAVES - PAINTED NATURAL BRANCHES - STEMS	1- BROKEN STEM/LEAVES - needs attachment - LEAVES attached on end stems w/ WIRE
10	grass	DRY, NATURAL, SOME PAINTED	VERY DRY BUT PRETTY GOOD - Splattered paint on surface to integrate? - **CRACKS IN BARK (AT BACK +

Figure 13. Survey condition form for foreground materials, in process.



To carry out the survey, close examination of specimens was essential. Among the greatest challenges of this project was the difficulty of reaching the materials in the diorama interiors without causing damage to them. Walkways had to be custom built to provide adequate access to examine specimens and wall-paintings, while avoiding grasses, bushes and other fragile groundcover and over-hanging vegetation (Fig. 14). This was accomplished with the careful work of the Exhibition Department preparators, who utilized lightweight “Bronco” sawhorses [1] with padded feet, as support for plywood walkways.



Figure 14. Walkway for access to specimens in Water Hole Diorama.

## 6. Environmental testing

Dioramas, because of the individual lighting and the specimens contained within, are unique environments; however, like the collection of galleries in any individual museum, they share numerous characteristics, both chemically and thermally. To understand the dynamics of these factors, selective testing was carried out to detail air and particulate quality within the dioramas, particularly to determine the level of protection needed for those working in them.

Air sampling for volatile organic compounds was conducted before opening the cases in order to ascertain whether, in the relatively tightly sealed enclosures, there had been a build-up of substances related to prior insect eradication techniques or preparation methods. After removing the diorama fronts, wipe samples were taken of the dust build-up on specimens and foreground materials, again to detect residues of insect control materials such as arsenic or mercuric chloride, and of asbestos, which was commonly utilized in the fabrication of certain foreground materials [2], which were also directly sampled for analysis.

Although the level of VOC's detected from air sampling was far below OSHA standards, numerous substances such as xylenes, trimethyl benzene, toluene and acetone were detected from the air sampling, presumably the residues of preparation and prior cleaning techniques. Arsenic had almost certainly been used on the skins in the field and during preparation and, indeed, low levels of arsenic as well as lead were detected. Asbestos was routinely utilized in the museum, for example in maché mixtures for the fabrication of diorama floors and sculpted elements such as rocks. Although expected to be present, asbestos was not detected in the circulating air, settled dust or maché samples.

Gaining an understanding of the interplay between the diorama lighting, ambient temperature and relative humidity was a critical part of the investigation. Their relationships proved to be interesting, given the relatively tightly sealed environments. Prior to the survey, data loggers had been placed in the diorama interiors and light boxes to record temperature and relative humidity. This information provided critical background for our specialists in all areas. It became clear that the key to preserving these exhibits would likely involve major modification of the equipment that controls these fundamental components.

One indication of Akeley's prescient forethought in planning the hall relates to his specifications about the environment in order to promote preservation. Letters in the archives document his desire to keep the hall at 60 degF. After his death, over great objections by Akeley's wife, heaters were added to protect the exterior walls behind the dioramas from 'sweating' and deteriorating (Faunce 1931, July 17). She wrote that Akeley expected there to be a ventilation system within the light boxes to dissipate the heat, thereby preventing condensation within the walls (Akeley, M. 1931, July 22). This ingenious ventilation system was not provided and, as a result, the lighting contributes greatly to the heat buildup found within the dioramas.

As might be expected, internal temperature in the dioramas was quite high year-round. It frequently exceeded 80 degF, particularly in those dioramas whose scenes depict locales in full daylight. Seasonal fluctuation in relative humidity mirrored that seen in other non-climate controlled parts of the museum and ranged from below 20% to about 65%. There were additional daily fluctuations in both temperature and relative humidity from turning off the diorama lighting at night. It was obvious from the data logger results that the lighting was the cause of both the high heat loads and environmental cycling.

Consideration of the diorama lighting became one of the more interesting and challenging aspects of the project because changes to enhance preservation would require innovation. The lighting scheme for these dioramas was, from the beginning, considered integral to the interpretation of the habitat, supporting the overall atmosphere of the original location, including time of day, season and weather variations. During the original planning Akeley specified that incandescent spotlights and floodlights be utilized to simulate natural light. Frances Jacques, one of the museum's background painters, stated that 'modern electric light is yellow and insufficient in comparison with daylight' (Jacques 1931, 9). Letters in the archives indicate that there was considerable confusion and lack of decision about the type of lights to illuminate both the dioramas and the hall itself. Ultimately, incandescent spots and floods with specially made reflectors were utilized.

These fixtures, however, were recognized soon after installation to be problematic. They produced too much heat, leading to cracking of glass in the light boxes and to fading of specimens. Combining the incandescent fixtures with newly invented florescent lighting was done soon after the hall opened, probably in 1945. The fluorescent lights were thought to simulate the reflected blue of the sky. The wavelengths provided by the incandescent fixtures were thought to simulate the warm tones provided by sunlight. The same lighting scheme exists today, as a combination of linear fluorescent fixtures to wash the center of the diorama, augmented by incandescent R lamps and tungsten halogen PAR lamps, all sources of either high heat, infrared and/or ultraviolet illumination. Filtering to remove ultraviolet emissions from the lighting sources was not provided.

Because lighting is fundamental to the visual perception of each group, the project participants considered it important to document the current layout of the lights, as well as the amount of illumination and the direction of illumination of each fixture (Fig. 15). These diagrams would serve as models for any new lighting scheme. Light level readings on each specimen were also documented and, in spite of the high heat load, current actual light levels were surprisingly low, seldom exceeding 20 foot candles and, frequently as low as 3 or 4 foot candles of illumination.

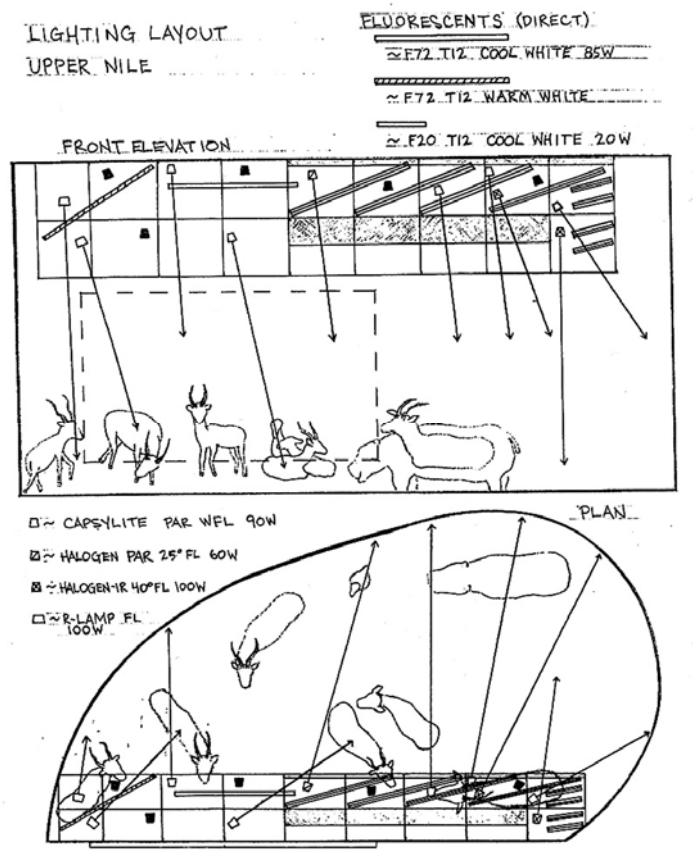


Figure 15. Diagram of current lighting scheme in Upper Nile Region Diorama, indicating type of fixture and direction of illumination.

## 7. Survey results: Specimens, wall paintings and foreground materials

Several generalizations can be made about the condition of the specimens, wall paintings and foreground materials within the dioramas. All are in relatively good condition, though uniformly quite desiccated. Damage from the environment has been far less catastrophic than expected. A thin layer of dust covers original surfaces, but this has an almost negligible effect on the viewer's experience.

Damage to animal specimens was found to be minor, except in the case of the elephants. Early treatments to eradicate pests in the preparation of the skins appear to have been effective in protecting most of them for the last 75 years. Little insect damage was observed and no active infestations have occurred in at least 20 years. Only a limited number of specimens, such as the hippo in the Upper Nile diorama, exhibited extreme damage, such as massive cracking through the skin (Fig. 16). These cracks were exacerbated by subsequent attempts at repair and restoration, which was frequently found to be the main source of current condition issues.



Figure 16. Cracked skin of hippopotamus in Upper Nile Region Diorama.

Ultraviolet illumination was used to help sort out and distinguish original materials from those used during undocumented restorations. Both original materials and materials used during prior restoration (which included waxes and oils, paints, natural and synthetic resins), seemed to have fared poorly and become unstable as they aged. For instance, fills to damages in skins or fills around noses, horns and other features applied during either original taxidermy or as later restoration were found to be dry, chipping and shrunken (Fig. 17). During restoration many of these fills, as well as furs in some cases, were over-painted, and the various applications can frequently be distinguished. Some specimens have a layer of now-insoluble resin applied to make them appear more glossy or wet, such as on rocks and the noses of animals.



Figure 17. Cracks and loss of fill around horn in White Rhinoceros Diorama.

Slight fading of furs was documented in numerous specimens, but more often than not the fading is uniform. This level of damage is generally perceived to be an acceptable result of aging. One exception to this generalization is seen on the zebra skins in the Waterhole Diorama, where more obvious pattern fading has occurred due to the overly bright, unfiltered light. Comparison of the tone of the now-brown zebras with the wall painting behind them, as well as comparison of the upper surfaces of the skins with the shadowed undersides, fairly indicates the degree of fading.

The background paintings were similarly desiccated and on the surface of paintings with high stipple, such as that painted by Robert W. Kane in the Wild Hunting Dogs case, a very fine crystalline layer could be seen as a glistening in raking light. These crystals were sampled and analyzed and are hypothesized to be deterioration products of oil paint [3]. Their presence is thought to be the result of the overly wet cleaning that took place during the 1980's treatment, as described by a preparator who was present (Quinn 2005; Schwartzman 1985). The components of deterioration were probably solubilized and then drawn to the surface as efflorescence as the diorama environment dried out.

A minimum of structural instability, such as cracking in the substrate or unstable paint layers, was seen in the paintings. There has been little previous restoration, but where it appears to have occurred, it creates visual confusion.

Similar to the other elements within the dioramas, the foreground materials were desiccated. As was to be expected, natural grasses and moss were highly brittle, easily breaking upon contact. Their colors were faded, often over painted during prior restoration and their appearance is now dulled by dust accumulation. Fabricated leaves exhibited minor distortion from aging. Some of the wax/cotton leaves were drooping and plastic leaves were curling (as do cellulose acetate leaves formed using early fabrication methods; Fig. 18). Given the deleterious environment, however, these materials seemed to have fared remarkably well.





Figure 18. Curling leaves in Mandrill case.

Unfortunately, the condition of the elephants was found to be poor compared with those specimens buffered from the effects of the environment within the diorama enclosures. The effect of uncontrolled ambient environment is clear. Some of the tusks are cracked, the skin has advanced red rot and large areas of skin on the ears are very unstable (Figs. 19-21). Additionally, enormous dust-bunnies generated by fibers shed from visitors' clothing necessitate twice-yearly vacuuming, which can contribute to mechanical wear and damage.



Figure 19. Red rot on elephant's leg in mounted elephant group.



Figure 20: Deteriorated skin on elephant ear mounted by Akeley.



Figure 21. Loss along edge of baby elephant's ear in mounted elephant group.

The mounted elephants provided the only clear example of structural damage observed during the survey, providing an interesting study within the study. Cracking is present at the join of the tops of ears to skulls in four of the elephants, those that were mounted by William Rockwell, a follower of Akeley's. In order to investigate the cracking, in-situ digital radiography of the ears mounted by both Akeley and Rockwell was performed, comparing them for differences in technique and, hence, in condition [4]. A handheld x-ray tube and an x-ray receptive plate were rigged on a variety of lifts to achieve access to the tops of skull and ears (Figs. 22, 23).



Figure 22. Digital X-radiography in progress.



Figure 23. Digital X-radiography in process – x-ray image of internal mounting of ear seen on computer screen.

It was found that the Rockwell ears were mounted using a heavy wire mesh screen on the back surface of the ears, while Akeley utilized a finer mesh that was inserted between split layers of the skin. Also differing from Akeley's well-integrated mounting scheme, Rockwell utilized a heavy iron rod for help with shaping and the rod was not tied into the internal armature within the skull. The cracking of the skin seen on the surface of the Rockwell heads was clearly the result of the skin separating due to gravity pulling down the weighty, cantilevered ears.

## 8. Recommendations

The final process of the conservation survey was to develop a plan for long-term preservation of the hall. Since the majority of specimens, wall paintings and foregrounds were not severely damaged, plans for treating these specific elements were relegated to the final phase of a future renovation. Most of the deterioration was caused by environmental conditions; hence, the most critical measures to bring about improvement consist of modifications to the HVAC and lighting systems. The challenge in implementing these changes is to create a balance between long-term preservation and preservation of the original intent of the dioramas (which included dramatic lighting effects), given the commercially available lighting options and feasible physical and financial modifications to the HVAC infrastructure.



Concerning the HVAC, the provision of humidification was an easy recommendation, as the current system, installed in 1995, provided only air-conditioning for human comfort. During the survey, air infiltration tests were performed [5] in order to investigate the extent of supplementary duct-work that might be required to bring conditioned air behind and above the dioramas. It was determined that with the provision of doors at all four entrances to the hall, little additional ductwork would be required and passive circulation of the fully conditioned air would flow behind, above and into the dioramas. Fans and vents supplied at each end of a run of dioramas would remove heat generated by the lighting.

For the lighting, the goal was to identify a combination of fixtures that would reduce the amount of heat generated, while maintaining flexibility in terms of spread, color temperature and level of illumination. Also important was the desire to identify longer lasting bulbs for economy and in response to the difficulty of accessing the light attics. As mentioned above, ventilation of the light boxes to further reduce heat build-up, as well as the provision of ultraviolet filters were also considered mandatory improvements.

The particular lighting scheme that proved to be successful was a combination of linear and compact fluorescent bulbs with high intensity discharge lamps. The fluorescent fixtures provided overall illumination within the diorama without changing the color temperature, and therefore the interpretation, of the painted scenes. The high intensity discharge lamps were used for spot illumination. The color temperature of the HIDs or metal halide fixtures approximates that of natural daylight and is much more efficient than incandescent or halogen light sources. Both of the light sources used have virtually no infrared component and are very economical in terms of output and power consumption, making them appropriate choices for long-term lighting of fragile museum specimens. Filtering of the relatively high levels of ultraviolet radiation emitted from these fixtures, as mentioned above, is necessary.

To ascertain the efficacy of this new lighting fixture combination, prototypes were made by re-lamping both a large, bright corner diorama and a smaller, shady diorama. Curators, exhibition designers and others were invited to view the prototypes. All agreed that the quality of lighting was actually better than in the present lighting scenario, as it brought out certain features of the specimens, such as the iridescent qualities in feathers, and it seemed to enhance the almost surreal sense of 'being there'. Furthermore, the heat load generated by the prototype lighting was reduced by more than 50%. The decision was made to upgrade the lighting in the dioramas following these models when renovation of the hall is undertaken.

## **8. Conclusion**

The Akeley Hall project can be seen as a model for carrying out this type of large-scale documentation survey. Conservation proposals have been detailed and will be executed pending funding. Environmental modifications are to be undertaken first, as they will benefit long term preservation of all the exhibits, followed by treatment of the elephants. Treatment of the dioramas is not presently deemed as critical as that of the elephants because the minor dirt and damages barely result in aesthetic disruption.

The aesthetic and scientific wonders presented in this multi-faceted exhibit are a testament to Carl Akeley's far-reaching vision and technical ingenuity. The most appropriate way to honor his achievements is to implement the survey's recommendations to ensure the future preservation of the Akeley Hall of African Mammals (Fig. 24).



Figure 24. Overall view of Akeley Hall

### Acknowledgements

The authors would like to extend their thanks to the Getty Grant Office for their generous support of this project and to all of the wonderful project participants for their contributions.

American Museum participants included: Judith Levinson, co-Project Manager and Head Conservator, Division of Anthropology; project conservators Sari Uricheck and Eugenie Milroy; Exhibition Department co-Project Manager Steven Quinn; Exhibition Department preparators Tory Ferraro and Steven Secka; Exhibition Department lighting designer David Clinard. Additional project support was given by Kala Harinarayanan, Director of Environmental Health and Safety and Dennis Finnin, Director of Photography Studio.

Project consultants included: Catharine Hawks, natural history conservator; Harriet Irgang, paintings conservator (Rustin Levenson Art Conservation Associates); Steven Weintraub, environmental conservator (Art Preservation Services); and Ernest Conrad (Landmark Facilities),

engineering and HVAC analysis. Scientific analysis was performed by Orion Analytical and GCI Environmental Analytical; air infiltration testing performed by Ambient Group, Inc.; occupational safety consultation by SOMA; digital x-radiography by Eklin Medical and Canon USA.

## Endnotes

1. “Bronco” sawhorses are manufactured by Reechcraft, P.O. Box 2426, Fargo, N.D. 58102, 888-600-6160.
2. Sampling carried out by GCI Environmental Advisory, Inc.
3. Analysis performed by James Martin, Orion Analytical.
4. X-radiography performed by Eklin Medical, with support of Canon USA.
5. Air infiltration testing performed by Ambient Group.

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## **THE DOCUMENTATION OF ADHESIVES IN THE WHOLE VESSEL POTTERY COLLECTION AT THE ARIZONA STATE MUSEUM**

Julie Unruh, Tara Hornung, and Stephanie Ratcliffe

### **Abstract**

The Arizona State Museum's whole vessel collection contains ceramics from nearly every cultural group in the American Southwest, including the type collections for two major prehistoric cultures. A project is underway to rehouse the entire 20,000-object collection in a purpose-built storeroom. Because it is the most comprehensive collection of its kind, the project received a "Save America's Treasures" grant in 2000.

In preparation for the move, the condition of each object is being recorded in a "Pottery Project" database. In addition to identifying conservation concerns, the survey phase of the project includes gathering statistics on features of interest to the conservation lab and other researchers from the 20,000-object sample base.

As a part of the project, all adhesives used in the collection are being identified and documented by staff and students. An assembly-line system has been developed to deal with thousands of adhesive identifications, including ethnographic repair materials (resins and plant gums), adhesives used by archaeologists and collectors, undocumented adhesives used by the Museum, and assembly adhesives used by contemporary potters. The process is primarily low tech, utilizing spot tests, UV examinations, and solubility. Select adhesives receive further instrumental analysis.

A searchable and sortable Access database was designed to collect the data. At the end of the survey, the database will be able to instantly:

- provide a library of adhesives used in the collection over the past 100 years;
- provide statistics regarding the frequencies of usage of specific adhesives within the collection;
- provide a timeline of adhesives usage within the collection;
- identify regional and cultural use of particular ethnographic repair adhesives;
- identify trends in adhesive usage in Southwestern archaeology.

### **Introduction**

The Arizona State Museum holds one of the most comprehensive collections of Southwestern Native American ceramics in existence. The whole vessel collection contains 20,000 complete vessels from nearly every cultural group in the American Southwest, including the type collections for the Mogollon and Hohokam prehistoric cultures. Unfortunately, the collection is housed in inadequate storage with little climate control, and as a result the collection has incurred damage from soluble salts, abrasion, adhesive failure and breakage. Because this collection is a

significant cultural resource, funds were raised to rehouse the collection in a purpose-built storeroom. The project, called the “Pottery Project” by the Arizona State Museum received a “Save America’s Treasures” designation in 2000.

In preparation for moving the collection, every pot is being surveyed and a condition report written. In addition to identifying conservation concerns, the survey phase of the project is an opportunity to gather statistics from the 20,000-object sample base on features of interest to the conservation lab and other researchers. As one facet of the project, conservation staff and students are endeavoring to identify and document every adhesive used in the collection. The adhesives fall into two groups: ethnographic repair materials, applied by the cultural groups who used the pottery; and adhesives used by archaeologists, collectors, and conservators at the Museum and elsewhere. The vast majority of these adhesives are completely undocumented. The Pottery Project has given the Arizona State Museum an unprecedented chance not only to identify these adhesives, but to put them into a searchable, sortable database for easy access by researchers.

Because thousands of adhesives must be identified, out of necessity the identification procedure was designed to be as quick and uncomplicated as possible. It is helpful that the presence of certain adhesives can be anticipated. It is known that cellulose nitrate was used by many archaeologists working in the American Southwest from at least the 1940s onward. Adhesives commonly used by early restorers, such as animal glue, and by later conservators, such as the PVOH derivatives and the acrylic copolymers, were also anticipated. Research revealed that a variety of ethnographic adhesives could be expected, including an animal adhesive made by boiling bighorn sheep horns, cactus gums from a variety of cacti and cacti fruits, piñon pine pitch, natural tar, waterproofing adhesives involving a mixture of sea turtle fat and cactus gum, and “creosote lac”, a lac secretion from a scale insect that lives on creosote bushes.

With these possibilities in mind, an adhesive identification system was developed based on three simple and inexpensive procedures: UV examination, solubility, and microchemical spot tests. Identification can be done quickly in an assembly line fashion. Figure 1 is a chart of the process for eight of the most regularly encountered adhesives.

All materials testing involves common sense. While a common sense assessment would seem to go without saying, in an assembly line process, there is a danger that the tester will blindly follow the steps without thinking about whether the identification makes sense for the time period and the visual appearance of the adhesive being tested. Conversely, the tester must keep an open mind. In several instances an “ancient” repair turned out to be a modern repair material.

As the beginning of the process, the visual appearance of the adhesives in a group of ceramics to be tested is noted.

The ceramics are then examined under UV light. In some cases, the visual appearance and the fluorescence color together can be enough to allow a good guess as to the identification of the adhesive. In any case, the color of the UV fluorescence determines the next step in the program of testing. UV examination as the “first pass” is additionally helpful in that it reveals adhesives undetected by the naked eye, uncovers multiple campaigns of repair requiring individual testing, and alerts the tester to good sampling locations (Fig. 2).

Adhesive	Fluorescence	Solubility	Spot tests
Animal adhesive	bright white	Water (hot water). The older it is, the longer it will take. May smell like animal glue.	Protein: Copper (II) sulfate
Asphalt & natural tar)	orange	petroleum distillates (petroleum benzine, stoddard's solvent)	none yet
Cellulose nitrate	yellow, milky white, yellow-green: can be dull, can be bright	acetone	Nitrates: diphenylamine test for nitrates
Creosote lac	orange	1 M NaOH	none yet
Epoxy	bright white	insoluble; may swell in methylene chloride	look for nitrogen with CaO <sub>2</sub> and pyrolysis; look for a positive with the PV(OH) test
Natural plant resins or gums	none to yellow-green: can be dull, can be bright	ethanol	none yet
Pine resin (rosin)	none to yellow-green: can be dull, can be bright	ethanol	Rosin: saturated sugar and sulfuric acid
PV(OH) derivative	a range: milky white, bluish, greenish, yellowish, no fluorescence	acetone; also may be insoluble	PV(OH) derivative: KI/I <sub>2</sub> and glacial acetic acid

Figure 1. Identification parameters for eight adhesives in the Arizona State Museum collection.



Figure 2. A Tarahumara pot with an ethnographic repair. Under UV, it is clear that there are two adhesives: a green-fluorescing adhesive over an orange-fluorescing adhesive. The color of the fluorescence determines the next testing step. Photograph by Margaret Kipling.

Assessing fluorescence color is subjective, but by evaluating enough adhesives, the tester is able to formulate a good individual



sense of color. Though an adhesive reference set is available to the project, it was felt that it had limited use. More useful is experience. Over time, in a collection in which the same adhesives are seen repeatedly, it was found that testers are able to develop a good personal knowledge of the appearance of various adhesives under UV light.

The results of the UV examination determine the next steps in the testing process: solubility and spot testing, often done simultaneously. All of the spot tests used are published in “Materials Testing for Art and Archaeology” (Odegaard et al. 2000). The authors discuss the spot test procedures, chemical reactions, reagent preparation, and safety precautions in detail; accordingly, those topics will not be discussed here. However, some published procedures were streamlined, and those modifications are described below.

**Procedure 1: Visual assessment: plastic-like, transparent, whitish, yellowish**  
**UV fluorescence: bluish, greenish, yellowish, no fluorescence**

By far the most common adhesive in the Arizona State Museum collection is cellulose nitrate. Cellulose nitrate was used by virtually all archaeologists working in the Southwest during the 20<sup>th</sup> century, and its occasional use continues until the present day. Cellulose nitrate can fluoresce a range of pale colors including blue, green, and yellow; and also has been observed to have almost no fluorescence. However, combined with an assessment of the appearance of the adhesive in visible light, a fairly good guess as to its identification can be made quickly. The guess can be confirmed in seconds with the diphenylamine test for nitrates (Odegaard et al. 2000, 164 -165). The published procedure was adapted in order to do the spot test on a swab. Since cellulose nitrate should be soluble in acetone, a small amount of the sample is picked up with an acetone swab. Note that this is also a solubility test. If the sample does not dissolve enough to be picked up on a swab, then the adhesive is unlikely to be cellulose nitrate. The diphenylamine reagent is dropped directly onto the swab. The characteristic blue color which indicates a positive will develop directly on the cotton.

The diphenylamine test can also give a positive for nitrate salts in the ceramic fabric. However, conscientious sampling techniques combined with an awareness of the potential for salts in the pot allow the tester to be fairly certain that a positive indicates nitrates in the adhesive, rather than nitrates in the ceramic. A control swab, swabbed on the surface of the ceramic rather than on the adhesive, can be helpful.

If the adhesive has a cellulose nitrate appearance and fluorescence but the diphenylamine test is negative, a good second guess is a poly(vinyl alcohol), or PVOH, derivative. This class of adhesives includes the poly(vinyl acetate) (PVAC) adhesives such as the AYA- series adhesives (Union Carbide) used in conservation; PVAC craft glues such as Elmers Glue-All (Borden), and some wood glues. The spot test for PVOH uses two reagents, glacial acetic acid and potassium iodide (Odegaard et al. 2000, 166 -167).

Trials were run to determine whether the PVOH test could be successfully performed on a swab. While it was found that it was possible to produce a positive reaction on a swab, in the end it was decided that, for two reasons, it is better to perform this test in a spot test plate as published. First, PVOH adhesives can be only marginally soluble, or even completely insoluble, in acetone.

If that is the case, an acetone swab may not pick up a good sample, though the test may still be successfully performed on a solid sample taken in the conventional way with a scalpel. Second, the positive reaction is a red color which may be faint, or may form only at the edges of a sample. If so, the reaction is more likely to be visible on a solid sample under magnification rather than on a dissolved smear of sample on a cotton swab.

The PVOH test will also give a positive for starch, and a positive for at least some epoxies. However, if the tester is paying attention to solubility and fluorescence, there should be no confusion with these materials.

If the spot tests give a negative for cellulose nitrate and a negative for a PVOH, the next guess might be that the adhesive is an acrylic adhesive such as Acryloid B-72 (Rohm and Haas). There is no spot test for acrylics, though fluorescence and solubility provide clues for its identification. It was fortuitous for the project that at the Arizona State Museum, the advent of acrylic use was approximately the same time as the advent of good conservation documentation. Consequently, in the Arizona State Museum collection, it has usually been possible to positively identify acrylic adhesives via the conservation documentation. In other situations, documentation will not exist. It is hoped that a spot test to identify acrylic polymers will be developed in the future [1].

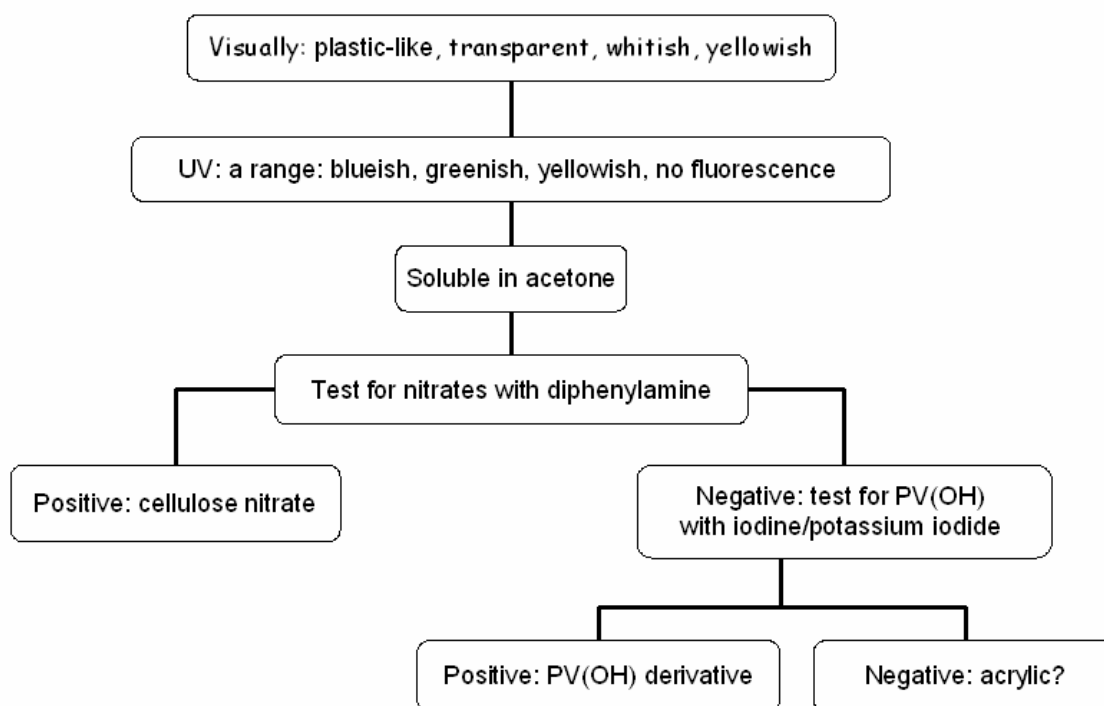


Figure 3. Testing flow chart for adhesives which are visually plastic-like, transparent, whitish or yellowish, and which are pale blue, green, yellow, or have no fluorescence under UV light.

**Procedure 2: Visual appearance: transparent to dark brown**  
**UV fluorescence: white**

In the Arizona State Museum collection there are two main adhesives that fluoresce white: animal adhesive and epoxy. They are not similar visually. If the tester is paying attention, all subsequent testing after the UV examination should be a confirmation of what is already suspected.

Animal glue is water soluble, though the solubility decreases with age. Nonetheless, solubility can usually be confirmed in seconds with a damp swab. (Hot water may dissolve more adhesive than room temperature water.) The identification is then double checked with the Biuret test for protein using copper II sulfate and sodium hydroxide (Odegard et al. 2000, 144 -145), which can be done directly on the swab, as for the nitrates test.

Odegard et al. lists a second test for protein using calcium oxide and pyrolysis (142 -143). That test is actually a test for bound nitrogen. Epoxies contain nitrogen. Consequently, if that test is used to identify a protein adhesive, an epoxy can give a false positive (and note that both epoxy and animal glue fluoresce white, further confusing the issue). In fact, this situation is helpful. There is no spot test for epoxies. However, two tests have now been identified which may give a false positive for epoxy: the PVOH test discussed above, and the bound nitrogen “protein” test. If an adhesive does not seem to be soluble in anything and yet gives a positive for nitrogen as well as a positive for PVOH, a good course of action is to see if it reacts to methylene chloride. Epoxies will not dissolve in methylene chloride, but they should swell. (A convenient way to watch a reaction with any solvent is to put a small sample on a slide, cover it with a cover sheet, and wick in the solvent from the edge of the cover. In this way the solvent fumes are contained and less solvent is needed.) Under the microscope, swelling may be seen as movement of the sample rather than a dramatic change of dimensions.

Figure 4 presents the Procedures discussed above as a flow chart.

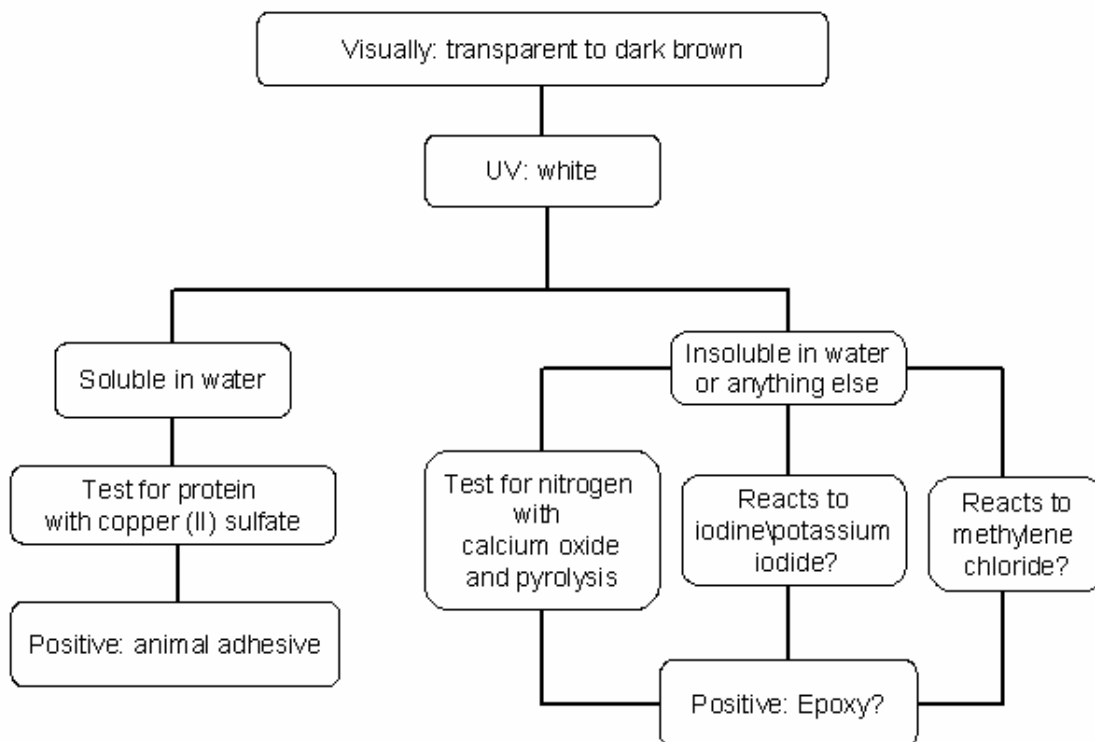


Figure 4. Testing flow chart for adhesives which are visually transparent to dark brown, and which fluoresce white under UV light.

**Procedure 3: Visual assessment: transparent to dark brown**  
**UV fluorescence: yellowish-green, green**

Substances that fluoresce greenish and are soluble in ethanol were suspected to be plant gums. In the Arizona State Museum catalog information, often anything that looks dark brown and fairly lumpy has often been assumed to be piñon pine pitch. Accordingly, as a point of departure, we began testing dark brown, ethanol-soluble repairs with the Raspail test for rosin (rosin is pine resin; Odegaard et al. 2000,158 -159).

The least destructive method for sampling any of the thick resinous substances in the collections was to take a “scratch test”. This sampling method uses a frosted microscope slide, cleaned with acetone to remove contaminants. The frosted end of the slide is swiped across the sample with light pressure, picking up a streak of residue on the surface of the slide. The test is then performed directly on the streaked slide and observed under a microscope. The benefits of this method are that the repair resin remains relatively undisturbed; and that, as for the swab sampling method, samples can be more easily taken from awkward sampling locations without needing to manipulate the ceramics unnecessarily.

The Raspail test for rosin indicates the presence of abietic acid. The sample is saturated in a saturated sugar solution, and then exposed to concentrated sulfuric acid. A positive reaction is raspberry red (a blue-red or cool-red color). The color can take up to 30 minutes to develop with low concentrations of abietic acid (aged samples), and false positives are common due to the warm red color that can develop simply from contact between the sample and the concentrated sulfuric acid. The testers found that it took practice to master the techniques and to learn the subtleties of color development.

While some of the greenish fluorescing ethnographic repairs tested positive for rosin, some did not. Nonetheless, because of the fluorescence, it was still suspected that they were plant adhesives of some sort, and a search began for a way to determine the presence of a plant material.

There is a simple test for carbohydrates using triphenyltetrazolium chloride or TPTZ (Odegaard et al. 2000, 134 - 135). Unfortunately this test it cannot be recommended. It was discovered that this test gave a positive for everything, including a blank, and this test was subsequently abandoned as a possible procedure for the project. A second test in the book for carbohydrates with o-toluidine (132 - 133) is actually a test for polysaccharides. Although this test will not identify every plant product, it should identify most of the gums and resins. Unfortunately, this test also was determined to be problematic: all the tests were either negative or inconclusive.

At this point one of the authors of the book was consulted (Zimmt, 2005). It is believed that the problem with the o-toluidine test may lie in the procedure, rather than in the test, and that there still may be some hope for using a revised version of this test in the process. However, until the problem is solved, this test still cannot be recommended. At present, we are left without a spot test to identify plant gum adhesives, or resins which are not pine resin.

In the end, Fourier transform infrared spectroscopy (FTIR) was used to identify some of the ethnographic adhesives. Obviously FTIR is not a solution for most museum labs. Again, it would be very helpful to have a conclusive test for plant-based adhesives. It is hoped that such a test can be identified in the future.

Figure 5 presents the procedures discussed above as a flow chart.

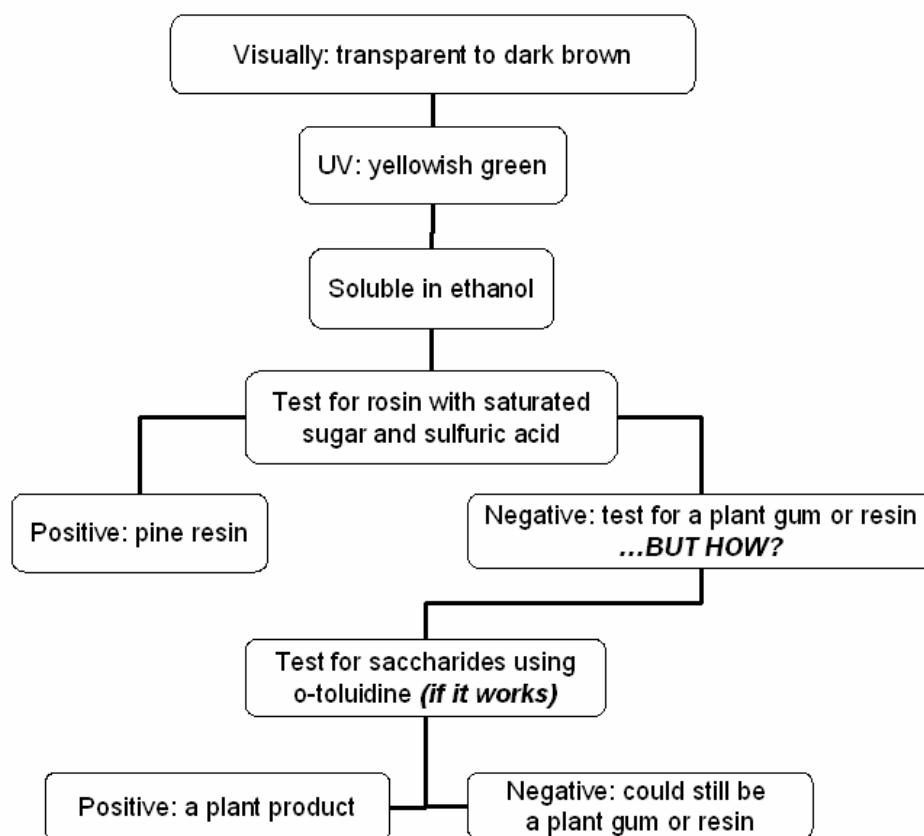


Figure 5. Testing flow chart for adhesives which are visually transparent to dark brown, and which fluoresce yellowish-green under UV light.

**Procedure 4: Visual assessment: dark brown, black**  
**UV fluorescence: orange**

In the Arizona State Museum collection, two adhesives have been identified which fluoresce orange. Surprisingly, neither one is shellac. One is natural tar or asphalt, and the other is creosote lac. There is no spot test for either of these substances. However, the UV and solubilities are so distinctive that there seems little chance for confusion. Neither is soluble in ethanol, which would indicate shellac. If the adhesive dissolves in one of the petroleum distillates such as petroleum benzine, then it is identified as tar. If not, solubility in 1M sodium hydroxide indicates creosote lac. Creosote lac is, like shellac, a lacquer which is secreted by an insect – in this case one which lives on creosote bushes. The creosote lac insect is related to the cochineal insect. Interestingly, when creosote lac dissolves in sodium hydroxide, a startling fuchsia color is usually, though not always, evolved. This distinctive color may be related to the cochineal dye, and the presence of the color or not may have to do with the purity of the lacquer.

Figure 6 presents the procedures discussed above as a flow chart.

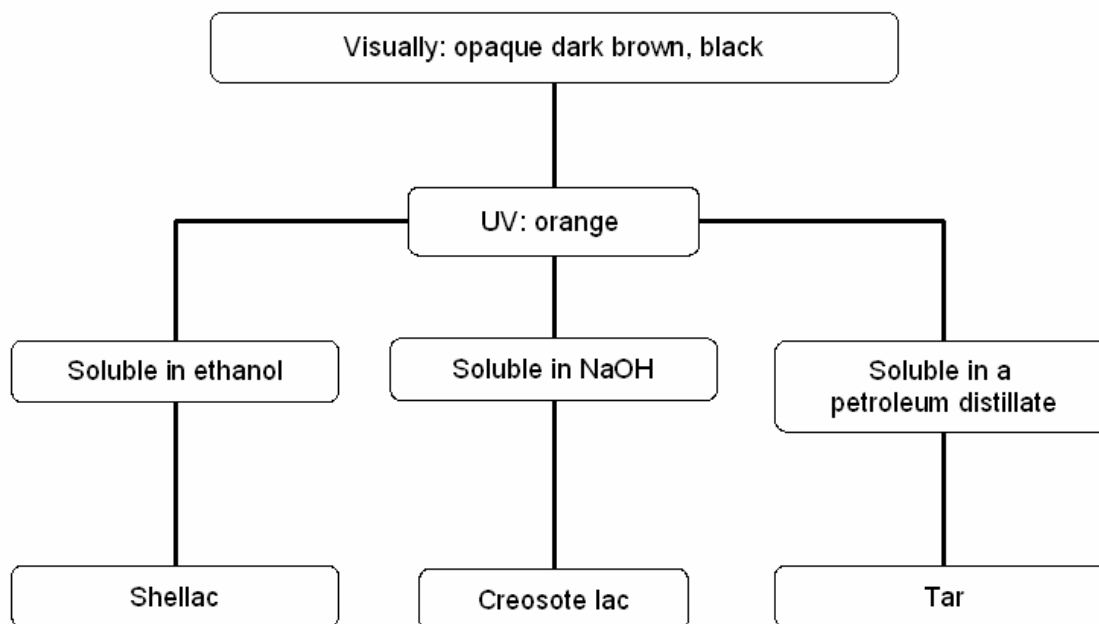


Figure 6. Testing flow chart for adhesives which are visually dark brown or black, and which fluoresce orange under UV light.

### Composite materials

As should be expected, many ethnographic repair materials are composite materials. In some cases, a mixture of fluoresces can be seen in one material under UV light. The individual ingredients cannot always be sorted out. This has been the case with a mysterious repair material which was recorded as “Mexican lacquer” in the catalog information. The material had a characteristic fluorescence under UV light, simultaneously green and orange, implying two different substances mixed together. The same distinctive fluorescence had been observed on repairs on several of the vessels from the Tohono O’Odham and Seri cultures in southern Arizona and northern Mexico. All of these repairs tested negative for pine resin.

“Mexican lacquer” is commonly used to refer to a type of folk art from Mexico created by applying colored varnish layers to wood or gourd. Multiple recipes exist for the varnish, which is called by a number of names, including “aje.” Mills and White (1999, 118) classify “aje” as an insect “resin” (their quotes) and report that aje is a boiled insect extract mixed with seed oils, but that “nothing is known of its chemical nature”.

A resinous sample in the conservation laboratory at the Arizona State Museum, collected in the Chiapas region of Mexico, was labeled “Mexican lacquer.” It was not further identified. It had

the same distinctive green and orange fluorescence under UV light, and also tested negative for pine resin. The sample was only slightly soluble in ethanol, swelled in acetone and was insoluble in Stoddard solvent. It was, however, completely soluble in sodium hydroxide.

FTIR analysis was inconclusive in identifying either component of our “Mexican Lacquer” sample, or even in determining whether either of the distinct fluorescences could be matched to a plant or animal product. However, ceramic repair materials with the same orange and green fluorescence did have an FTIR fingerprint similar to that of our sample, and they also proved to be soluble in sodium hydroxide.

Many clues pointed towards a component similar to creosote lac. (Note that creosote lac is not a boiled insect extract, but rather an exuded lac product.) One of the ceramics which produced a similar FTIR spectrum to the “Mexican Lacquer” sample even was described on the catalog card as “sealed with csipz (xsipx), a lac of creosote bush”. However, the dual fluorescences, the slight solubility in ethanol, and the inconclusive FTIR spectra convinced us that what we have is a mixture, very possibly the insect and drying oil mix described by Mills and White. The substance has yet to be positively identified.

In other cases, the documentation alerted us to the fact that the repair material is a mix. This was the case for a Seri material described as organ pipe cactus gum boiled with turtle or pelican grease (a repair material made for caulking boats).

An attempt was made to verify the catalog information. The gum proved impossible to conclusively identify, due to the unreliability of plant gum tests, as reported above. However, we were successful in determining the presence of a fatty acid, using a procedure developed by Werner Zimmt (2005), reported in Appendix A.

It is unlikely that we would have thought to test for the presence of a fat component had the catalog information not informed us of its presence. This is a warning sign that many of the ethnographic repairs may have constituents that are going unnoticed and untested. Supporting this suspicion is the fact that many of the FTIR spectra are inconclusive. They appear to indicate mixtures of materials; mixtures are not easily identified with FTIR. It must be emphasized that much work remains to be done with identifying ethnographic repair materials. It will be important to build a reference library of FTIR spectra for those materials.

### **The Pottery Project adhesives database**

A database should not just be a file of records. It should be a tool for looking at data in various ways. If the database is designed correctly, the data can be organized as needed to answer particular questions. The Pottery Project adhesives database was designed to:

- provide a library of adhesives used in the collection over the past 100 years;
- provide statistics regarding the frequencies of usage of specific adhesives within the collection;
- provide a timeline of adhesives usage within the collection;
- identify regional and cultural use of particular ethnographic repair adhesives;



- identify trends in adhesive usage in Southwestern archaeology.

All information collected for the Pottery Project, including the adhesives identification, is entered into one Microsoft Access database. From the main survey form, as each pot is surveyed, the adhesives information is input into an embedded Repairs “subform” (Fig. 7). The database is designed so that as many Repairs subforms as are needed may be linked to the main record for each pot. If there are multiple campaigns of repair, each repair is recorded in an individual record. The result is that all repairs, not just all pots, can be individually sorted and queried.

**SOUTHWEST POTTERY REPAIRS**

Prime #  Date:   
 Sort #:  Prepared by:

Cultural repair ☒ Date of repair (YYYY-MM-DD)  Reference:   
 Number of sherds extant:  Repaired by:

Adhesive  How identified?   
 Excess adhesive ☐

Surface coating:  How identified?

Fill material  How identified?   
 Overfilled ☐  
 Efflorescence adjacent to fill ☐

Inpainting medium  How identified?   
 Overpainted ☐

Other materials or problems:   
 Comments:

Record:      of 2

Figure 7. Repairs subform as it appears on the computer screen.

The database is able to sort by any of the fields in the “Repairs” form, and also by any of the fields in the related record for the pot. For example, if the database user asks the question: “What materials were used for ethnographic adhesive repairs?”, he can request that the database return a list of all records for which the “cultural repair” box is checked in the Repairs record, and for

which an entry appears in the “adhesives” field. Thousands of records will be instantly organized into a useful list. The records can be sorted by date of repair, producing a timeline of usage; or by the cultural group entered on the related main record, producing an inventory of adhesives used by that group, and so forth.

If the database user wants to ask the question, “what adhesives are archaeologists in the American Southwest using?”, he can request that the database return a list of all repairs made by archaeologists. If it is sorted by the date of the repair, it will be a timeline of adhesives usage in Southwestern archaeology. If it is sorted by archaeological site location (which is entered in the related main record), it will be a catalog of all adhesives used at a particular site. That information could also be further sorted by date, and so forth.

Any of this information could be downloaded to a compatible software program. For example, a list of adhesives and the dates of their usage can be downloaded into Microsoft Excel, a spreadsheet program. Excel could then graph the repair date data as an actual timeline, or graph the incidence of adhesives usage as a pie chart, or graph them both together as scatter graph showing the incidence of use over time. As we expect many thousands of records at the end of the project, the automatic graphing facility will be able to accomplish what would not have been otherwise possible: easily making a large amount of data comprehensible and usable.

## **Acknowledgements**

The authors would like to thank Nancy Odegaard, Peggi Cross, Melissa Huber, Sonya Issaeva, Maggie Kipling, Teresa Moreno, Caitlin O’Grady, David Smith, Werner Zimmt, Save America’s Treasures, The NAGPRA Grant Program, The Samuel H. Kress Foundation, and The George Stout Fund.

## **Endnote**

1. In our testing, HMG brand B-72, an acrylic copolymer adhesive, tested positive for nitrates with the diphenylamine test. This unfortunate fact was discovered when a ceramic known to have been repaired with HMG B-72 consistently tested positive for nitrates. Two tubes of HMG B-72 subsequently also tested positive. At present, no attempt has been made to identify the source of the nitrates in this adhesive.

## **Suppliers**

Chemical reagents used in the spot testing:

Fisher Scientific, 1 Reagent Lane, Fairlawn, NJ 07410, (201) 796-7100, Fax: 201-796-1329, ([www1.fishersci.com/index.jsp](http://www1.fishersci.com/index.jsp))

Hand held UV lamp:

several models available from Cole-Parmer Instrument Company, 625 East Bunker Court, Vernon Hills, Illinois 60061-1844, (800) 323-4340, ([www.coleparmer.com](http://www.coleparmer.com))

Microsoft Access database software, included in Microsoft Office Suite software packages: ([www.microsoft.com/products](http://www.microsoft.com/products))

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Mills, John S. and Raymond White. 1999. *The Organic Chemistry of Museum Objects*, 2<sup>nd</sup> Edition, Boston; Butterworth Heinemann.

Odegaard, Nancy, Scott Carroll, and Werner S. Zimmt. 2000. *Material Characterization Tests for Objects of Art and Archaeology*, London; Archetype Publications.

Zimmt, Werner. 2005. Personal communication. Arizona State Museum, Tucson, Arizona.

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## Appendix A: test for the presence of a fatty acid

Procedure for determining the presence of fatty acid:

- Add a drop of concentrated hydrochloric acid to a small sample in a spot test plate. Place in an oven until dry. This step hydrolyzes the sample.
- Dissolve the dry, hydrolyzed sample in a drop of Stoddard's solvent.
- Filter this solution through fluted filter paper in a funnel to remove solids. Transfer the remaining liquid with a pipet onto a clean microscope slide.
- Evaporate the liquid on a hot plate.
- Because the fatty acid is hydrophobic, if the material is a fatty acid, a drop of water will bead on the residue.
- Finally, a drop of 1M sodium hydroxide will dissolve the residue by neutralizing the acid.

## **THE CONSERVATION OF TUMBAGA METALS FROM PANAMA AT THE PEABODY MUSEUM, HARVARD UNIVERSITY**

Scott Fulton and Sylvia Keochakian

### **Abstract**

A grant awarded by the Institute for Museum and Library Services (IMLS) made possible a major conservation initiative for an important but very fragile group of tumbaga (gold/copper alloy) figurines from Veraguas, Panama (ca.1300-1500 A.D.). Approximately 70 of these small pendants required immediate attention due to unstable mount materials and restoration adhesives used in the 1930's and 40's. Cellulose nitrate (Celluloid) was identified as the primary mount medium to which the artifacts were adhered. The adhesive and consolidant was identified as a polyvinylacetal resin (Alvar). The predominant corrosion product was identified as basic copper nitrate.

Conservation treatment included methods that allowed the safe removal of the artifacts from their destructive Celluloid mounts. Earlier excessive applications of Alvar adhesive needed to be reversed or reduced and loose extant fragments required reattaching. The removal of basic copper nitrate corrosion products was effected on a local level using solvent gel techniques. Delaminated fragments of gilding trapped in glue and left behind on the Celluloid supports, was reclaimed by an unconventional backing technique using gossamer nylon and a cellulose ether adhesive. Each of the tumbaga figures was re-housed to promote safer handling for research and to facilitate access in storage.



Figure 1. Tumbaga pendant (PMAE# 51-57-20/ 19300).



Figure 2. 1938 S.K. Lothrop, Sitio Conte, Veraguas, Panama (PMAE# 996-20).

### The Collection

In 2002 a grant was awarded to the Peabody Museum by the IMLS to support an ambitious but much-needed conservation project: the stabilization and re-housing of the Central and South American metal artifacts collections. This paper describes a small but significant part of the larger effort to re-house the Peabody's collection of Latin American metals. The end result of this project was the stabilization of nearly 1600 metal artifacts. The affected artifacts were drawn from general Meso- and South American collections that are of archaeological and ethnographic significance, including precious metals from the Sacred Cenote at Chichen Itza, and unique early silver-alloy metalwork from Peru.

165 tumbaga artifacts from the area of western Veraguas in Panama received treatment during this project. Of this number 65 were of primary concern and are the subject of this paper. They first came to the Museum ca. 1935 as new excavations along the Pan American highway yielded fresh evidence of pre-historic cultures at several sites including Sitio Conte. The tumbaga objects are representative of metalwork dating from pre-conquest Panama, approximately 1300 – 1500 A.D., and are indicative of a high level of technical sophistication and skilled craftsmanship.

Explorations in Panama by Peabody Museum archaeologist Samuel K. Lothrop (Fig. 2) resulted in new accessions of tumbaga figurines through the 1940's and 50's. Cast in zoomorphic and anthropomorphic forms (Fig. 3) from alloyed gold and copper, the artifacts discussed in this paper were extensively restored and mounted shortly after they were acquired during the early 1940's and prior to being placed in exhibit cases. Later acquisitions during the 1950's were treated similarly and placed on exhibition as they were accessioned. Issues of inherent vice associated with the materials used for restoration and conservation of the objects were not well



Figure 3. Tumbaga figurines (left to right, PMAE# 50-19-20/ 13294 and 40-17-20/ 7554)

understood then. Over a span of nearly 60 years the choice of what were at the time “modern” plastics and adhesives proved to be detrimental to the long-term stability of the objects. The pendants were on display for more than three decades until the late 1970’s when they were de-installed and placed in plastic bags. This re-storage measure proved ultimately to exacerbate the existing problems due to the incompatibility of mounting materials (cellulose nitrate) with a fluctuating micro-climate inside the polyethylene bags.

The process of organizing and stabilizing the collection was started in 1996 with efforts to identify the constituent materials and arrest various chemical mechanisms that were contributing to their unstable condition. Earlier storage methods causing problems included housings made of unsound materials such as matchboxes, cigarette boxes and peanut cans; dense packing of artifacts with little or no cushioning; and housings that limited accessibility of objects to researchers (Fig. 4). The tumbaga collection became a focal point because of the obvious evidence of conservation problems related to unstable mount materials and adhesives. Treatment methods and protocols evolved and underwent modifications as the conservators became more informed about the fragility of the tumbaga figurines.





Figure 4. Old storage systems.

### Manufacturing techniques

Most of the tumbaga pendants have an open back but others are hollow and could have functioned as bells or rattles. They were cast using the lost-wax method (*cire perdue*). The form was modeled in wax including all details, while the reverse or “hollow” sides were left rough. The wax model was encased in a clay mold which was fired to bake the clay and melt out the wax, leaving a void to be filled with molten metal. Once the metal had solidified, the clay casing was broken up, and the object cleaned. The result was a unique and individual casting.

The surface color of the objects could be modified by a process called “depletion gilding” (*mise-en-couleur*), a gold surface enrichment. The cast copper-gold alloy figurines were treated chemically to remove the base metal from the surface of the object giving the finished piece the appearance of high purity gold. Either mineral salts or acidic plant extracts could have been used for this procedure. Depletion gilding produces a well bonded but porous and spongy layer only a few microns thick, which was then burnished. A higher copper content would result in a more reddish color and a higher gold content produced a more yellowish color.



### Historical perspective and current condition

Non-gilded archaeological metals having a high percentage of copper are known to survive in better condition than gilded tumbaga objects primarily due to galvanic forces and preferential corrosion between gilded layers and the underlying alloy in a burial environment. The less noble copper will eventually corrode, the resulting corrosion products will undermine the gilding, and the thin gilded layer may eventually become detached from the heavily mineralized base alloy. Earlier experimental treatments of the 1930's and 40's for copper alloy artifacts at the Peabody Museum, followed procedures that were in common use at the time. Conservation theory and practice at the Peabody was influenced by active sharing and collaboration with conservators across campus at the Harvard University Fogg Art Museum. Rutherford J. Gettens, conservation scientist at the Fogg Art Museum between 1928 and 1951, suggested methods for cleaning bronze antiquities using solutions of sodium sesqui-carbonate as a means of chemically reducing copper corrosion product (Gettens 1938). Frederick Orchard, Peabody Museum restorer and contemporary of Gettens, reported using another treatment for removing extraneous burial accretions using Calgon (sodium hexa-metaphosphate). In a 1938 letter to curator H.J. Spinden at the Brooklyn Museums, Brooklyn, NY, Mr. Orchard describes boiling thin-plated copper objects [tumbaga] in Calgon to remove corrosion (Orchard 1938). The entire artifact was then, according to Orchard, "dipped into a 5% solution of Alvar 7-70 in acetone." (Orchard 1938). The same resin in a higher percentage was used for reattaching extant fragments together and affixing the figurines to the mounts. More recent condition assessments of the Tumbaga collections have noted that Alvar resin that was applied heavily in earlier treatment campaigns, had yellowed considerably (Gates 2004). Furthermore, thickly applied layers of Alvar had shrunk, resulting in a mechanical "pulling away" of original gilding from the base metal (Fig. 5). Over time, the Alvar had become increasingly brittle and cross-linking had rendered it less and less soluble in organic solvents.



Fig. 5. Delamination caused by Alvar coating (PMAE# 37-57-20/ 5154).

Most of these artifacts were glued down to cellulose nitrate mounts (Orchard 1938). Joins were often reinforced with cellulose nitrate backing strips. Wax, plaster and possibly cellulose acetate were also used but only infrequently. The condition of the figurines adhered to the Celluloid mounts was of primary concern. Cellulose nitrate is inherently unstable and slowly deteriorates over time regardless of favorable environmental conditions, controlled or uncontrolled. Negative bi-products released by degrading cellulose nitrate include nitrous and nitric acid that, combined with high humidity, react with copper alloy metals to form bright blue-green basic copper nitrate salts. Typical characteristics of cellulose nitrate deterioration include dimensional change, warping, embrittlement, cracking, sticking and color change (Fig. 6).



Figure 6. Deteriorated Celluloid mounts (PMAE# 2002.1.1319).

Since the mid-1970s, when the Veraguas Tumbagas were taken off exhibit and placed in polyethylene bags for storage (Fig. 7), they had been trapped in a micro-environment subject to acid off-gassing from the cellulose nitrate mounts, thereby accelerating the corrosion. Corrosion of the alloy was more prominent at contact points with the aging plastic. Many breaks occurred where the Celluloid sheet warped, cracked and crizzled, and the brittle metal failed at stress points (Fig. 8).



Figure 7. Tumbagas as found in storage.



Figure 8. Damaged Tumbaga figurine (PMAE# 37-57-20/ 4903).

## **A conservation strategy**

In 1996, a pilot research project was initiated, focusing on several tumbaga figurines, to determine an appropriate conservation strategy for the collection. A treatment protocol was established to address several goals:

1. Removal of the artifacts from the destructive Celluloid mounts.
2. Removal as possible of excessive coatings and adhesives.
3. Reduction of nitrate corrosion.
4. Reattachment of extant fragments.
5. Reclamation of detached gilding from the old mounts and replacement on the artifacts.
6. Consolidation of friable core material and delaminating gilding.
7. Preparation of individual housings to provide safer access for researchers.

The first stage was the removal of the objects from their encapsulating plastic bags and thereby slowing down the corrosion process. Corrosion products and support materials were examined and identified, methods for separating the figurines from their mounts were investigated, and methods for reclaiming gilding stuck to the old mounts were tested, while various re-housing options were designed and tested.

## **Removal from old plastic supports**

The figurines were placed in an acetone solvent chamber (Fig.9a – 9c) to gradually soften the mount and the adhesive, and to facilitate removal of the object from the mount. After extended exposure to the acetone vapors, the mount and adhesive materials were usually softened enough to carefully peel the mount away. Remaining fragments could usually be removed by direct injection of acetone between the fragment and the mount, and by a final acetone bath.

## **Reducing corrosion**

The blue-green corrosion was first identified as basic copper nitrate salts mixed with copper carbonates by x-ray diffraction analysis conducted at the Department of Earth and Planetary Sciences, Harvard University. Identification of the plastic supports as cellulose nitrate was confirmed by FTIR in the Straus Conservation Analytical Lab, Fogg Art Museum, Harvard University. Corrosion was locally treated by combining mechanical and chemical treatment methods. Dilute formic acid was combined with various gel materials such as Klucel G (hydroxypropylcellulose), Methocel A4C (methylcellulose), Polyacrylamide (acrylamide, methylene-bis-acrylamide) in an effort to achieve better control and to limit contact with the surface area (Figs. 10, 11). Areas of corrosion that failed to respond to any of the methods were left alone. Minimal disruption of the gilded surface was achieved using these techniques.





Figure 9. Removal from old mount (PMAE# 39-31-20/ 6392).

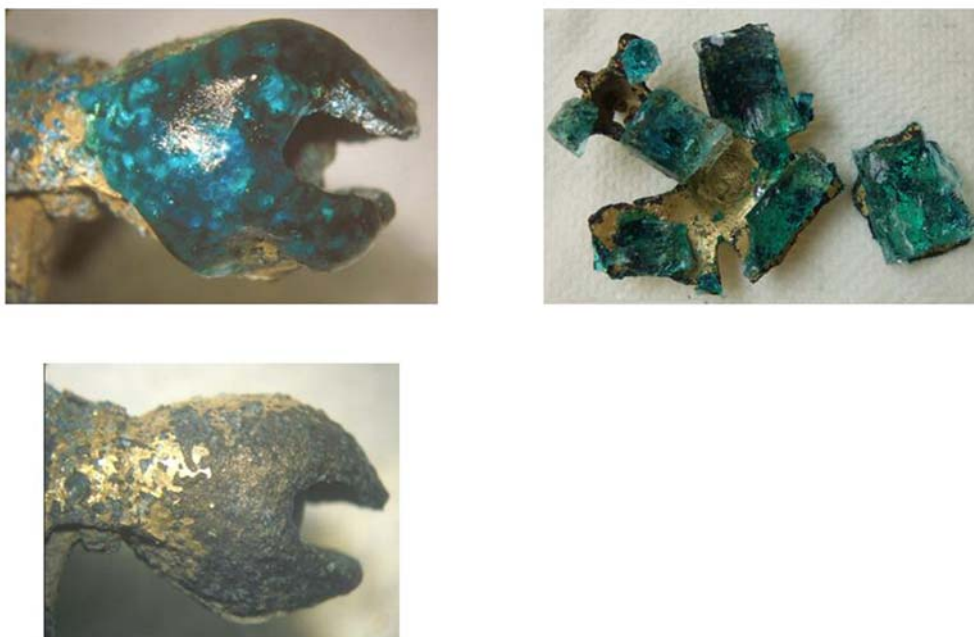


Figure 10. Corrosion removal using gel systems.

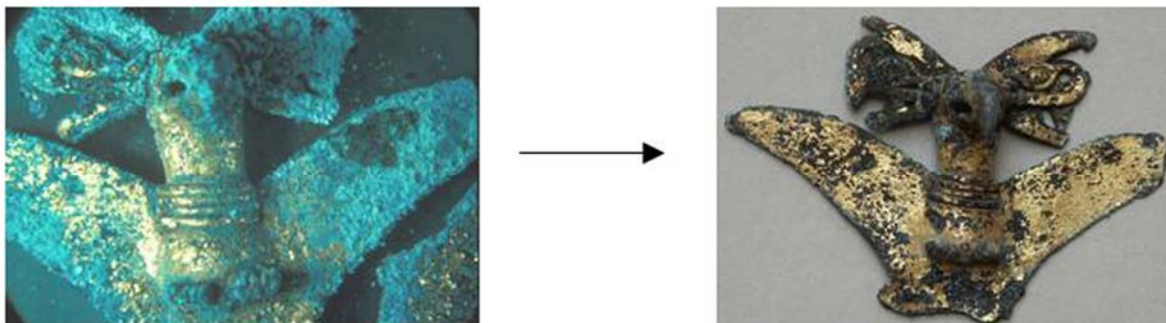


Figure 11. Corrosion removal before (left) and after (right) (PMAE# 40-17-20/ 7549).

### Reconstruction and reclamation

Extant fragments were reattached with Paraloid B48N (methylmethacrylate/butylacrylate co-polymer) (Fig. 12). Flaking gilding and brittle core material were consolidated with Paraloid B72 (ethylmethacrylate/methylacrylate co-polymer) in order to improve strength and integrity. Some joins were reinforced on the reverse side of the figurine with a backing strip of sheer nylon fabric (Cerex) adhered over the break edge. Gilding material that had become detached from the core material was reclaimed from the mount and reattached to the figurine (Fig. 13a - 13d). In preparation for reattaching the gilding, sheer nylon fabric was temporarily adhered with methylcellulose (Dow Methocel A4C) to the reverse side of the gilding. The mount with the gilding was placed into an acetone chamber for about 12 hours, an island around the gilding was cut out of the softened mount and placed into an acetone bath for several hours to dissolve remaining mount material. Excess fabric material was then cut away and the backed gilding fragment was positioned and reattached with Paraloid B72 over the area of loss.



Figure 12. Reassembling with gossamer nylon backing (PMAE# 54-1-20/ 19519).

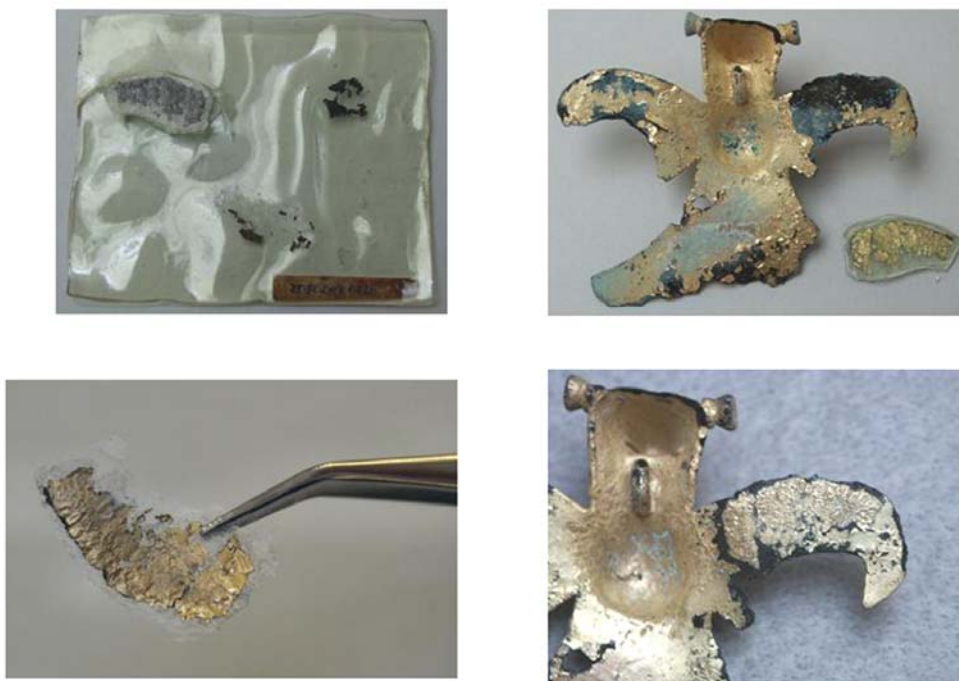


Figure 13. Reclaiming gilding from old Celluloid mount (PMAE# 39-90-20/6462).

### Storage mounts

After stabilization and treatment, the tumbaga objects were placed on custom made mounts made of archival corrugated board and nested in position between Plastizote foam bumpers (closed cell polyethylene foam) (Fig. 14). If extant fragments or gilding could not be reattached, they were stored in vials, labeled accordingly and stored with the artifact on the same mount. Condition and treatment reports were entered into the Peabody Museum's relational data-base, 4D-EmbARK, while the artifacts were returned, in new housing, to collections storage (Fig. 15). This conservation support project successfully saw to completion the stabilization and repair of 100% of the Peabody Museum tumbaga artifacts in storage. Furthermore, it made possible an essential re-housing campaign affecting the remainder of the Latin American metals collections that safely opens the collection to future analysis and study.





Figure 14. New storage mounts (PMAE#’s 39-90-20/ 6465, 6468, 19300).



Figure 15. New tray storage.

## Acknowledgements

Stabilizing the condition of the Peabody Museum's tumbaga collection was first recognized as deserving of priority status in 1996 when collections care initiatives turned to the environmental needs in metals storage as identified in a 1992 IMS Collection Condition Survey. Since that time, the initiative to improve the preservation of these fragile objects steadily gained momentum thanks to the focused hard work and commitment shared by several conservators, conservation scientists and collections care specialists who participated in various phases of the project over the last ten years. Their individual contributions are greatly appreciated: Esther Chao, William Croft, Glenn Gates, Amy Groleau, Cricket Harbeck, T. Rose Holdcraft, Laura Lipscei, David Lange, Erin McGough, Susan Peschken and Amber Tarnowski.

The authors also extend their gratitude to the following institutions and their support staff whose help was instrumental in the success of this project:

Institute for Museum and Library Services  
Peabody Museum of Archaeology and Ethnology, Harvard University  
Straus Conservation and Analytical Lab, Fogg Art Museum, Harvard University  
Department of Earth and Planetary Sciences, Harvard University

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## Suppliers

Polyacrylamide gel materials (Acrylamide; N,N- methylene-bis-acrylamide; Ammonium persulfate; N,N,N,N – tetramethylene diamine (TEMED):  
Aldrich Chemical Co., P.O. Box 14508, St. Louis, MO (800) 325-3010

Acryloid B-72, Acryloid B-48N:  
Conservator's Emporium, 100 Standing Rock Circle, Reno, NV 89511 (775) 852-0404

Methylcellulose, Nylon gossamer fabric:  
Talas, 20 West 20<sup>th</sup> Street, New York, N.Y. 10011 (212) 219-0770

Formic acid, reagent grade:  
VWR Scientific, Inc., 50 D'Angelo Drive, Marlboro, MA 01752 (800) 947-4270

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## **PROPERTIES OF FILLERS IN PUTTIES BASED ON ACRYLOID B-72**

Julie Wolfe and Talitha O'Connor

### **Abstract**

Bulking Acryloid B-72 with fillers to make putties can have great flexibility due to the enormous range of products available for this application. Individual characteristics of each filler type will modify the properties of the polymer in different ways. This paper presents an initial phase of research designed to study the effects of fillers in B-72, to understand the difference between bulking with carbonates, silicates, sulfates, or organic compounds. In this phase, the fillers and resin were chosen to represent a set of putties that could be used for loss compensation on white marble in an indoor setting. A systematic study has been limited to one resin mixture, 60% B-72 w/v in acetone, isolating a group of 21 different fillers. Sample coupons of the dried putties were tested to compare color, gloss, reflectance, and Vickers hardness. Compiling this data into a reference chart is ongoing. With continued study, the results should allow for improved comparison of their properties, enabling the conservator to choose the most appropriate mixture for specific treatments.

### **Introduction**

The long-term goal of the topic presented in this paper is to design a comprehensive palette of fill mixtures that can be used on indoor marble sculptures. The aim is to better understand the individual properties of fillers to allow conservators to approach filling more like inpainting. Ideally, fills that mimic the marble would eliminate the need for inpainting. Technical studies can additionally categorize fillers according to their mechanical and physical properties as they modify B-72. Classifying putties with specific filler types for their color, strength and workability could lead towards a practical database for distinguishing one or more fillers for a specific application.

The challenge in creating putties for loss compensation in marble is due to the fact that no two pieces of stone are exactly alike. White marbles are composed of dolomite and calcite with a wide variety of minerals affecting its color, texture and characteristic particle morphology affecting its translucency (Solomon and Hawthorne 1983). Since conservators work with marbles of such subtle variances, no one single recipe could suffice. Having a fill that mimics the appearance of marble is not the only desirable property. Adopting the list from John Griswold and Sari Uricheck (1998), the putty should also be workable, carvable, stable, reversible, non-shrinking, lacking air bubbles, and variable in hardness, color and translucency.

With the variety of fillers available, comparing their properties is a complicated technical study to control. As explained by Plueddmann and Stark (1977, 1), "the interface between polymer and filler involves a complex interplay of physical and chemical factors related to composite performance". Keeping in mind the interfacial relationship between the filler and resin polymer,

resin modifications based on solvent type and specific properties of the filler allow for an unlimited number of variables. Filler properties such as particle shape, particle size, and refractive index may modify the composite in hardness, translucency, color, slump and more. Within the conservation literature, there have been several studies on fillers in resins that have either focused on a limited number of fillers, or one mixture (Gänsicke and Hirx 1997; Nagy 1998; Griswold and Uricheck 1998; Larkin and Makidrou 1999). With these studies in mind, the authors hope to expand on their work with the aim of perfecting the putties for specific applications.

### **Strategy for the study**

The strategy in this study acknowledges the complexity of this topic and assumes the need to plan a series of phases that will systematically isolate the properties of each composite. This first phase attempts to reduce as many variables as possible by isolating one filler type, in one resin system, and one solvent. B-72 and acetone were chosen as the resin-solvent mixture. This is a common resin-solvent system currently used by conservators, the quick evaporation of acetone may prevent slumping in comparison to other solvents, and the authors have found that in use, acetone allows the putty to set up in reasonable working time. Putties were prepared and cast into sample coupons that could be used for testing as described throughout this paper. All were mixed in B-72 at 60% w/v in acetone. Each filler in turn was added to 30 ml of the resin-solvent mixture and the putty cast into three round coupons, 2 cm diameter and approximately 1/4" thick. These coupons were used to test hardness, color, gloss, and reflectance.

Variables were difficult to eliminate when preparing the samples, and as the goal was to test putties under real-life conditions it was impractical to follow industrial standards. Each recipe required different filler-resin concentrations to obtain workable putties. For example, fumed silica can be added to approximately 200% of the weight of B-72 before breaking apart, whereas a crushed marble can only be added to approximately half that quantity. The acetone solvent created another unavoidable variable in viscosities. During sample preparation, it was inevitable that the acetone would evaporate at different rates and cause the putties to have slightly different working properties. The viscosity of each putty was not measured during this phase, and the workability among them varied in texture and quality. Variables were minimized by having a structured routine for the sample preparation and one person preparing the coupons.

### **Choosing a resin concentration**

As Larkin and Makidrou found in 1999, different fillers require very different filler-resin ratios to give the best results. In order to determine one resin concentration for the study, it was necessary to test each filler in a range of concentrations and select one that would accommodate all of the fillers. Starting with 20% w/v and working up in 10% increments, we found that all of the fillers were best used in a resin concentration of 60% w/v. Having only tried between 20-60% w/v concentrations, we cannot generalize that this is the best concentration, however this small study did show the 60% as having the greatest range of workable putties at different filler concentrations and produced fewer samples that broke apart or cracked when dry. The

concentration study also helped to reduce the filler list from thirty to twenty-one, as it identified ones that were difficult to work with or could have complicated the study. Eliminated fillers are listed in Table 3 (all tables appear after the text).

### Choosing a filler concentration – the final recipes

The concentration for each filler varied since their capacities to bulk were different. As the resin concentration tests were being carried out, the authors determined the threshold limit for adding fillers to 60% w/v B-72. The filler was added in ¼ teaspoon increments to 30 ml of B-72 and a small sample was taken each addition of more filler. The procedure continued until a stiff putty could be worked without breaking apart as seen in Figure 1. During this process, the working properties of the wet putties were noted and can be found in Table 2 under the putty observation column. The putty was described as gritty, spongy, gummy or stiff/taffy. Wet putty texture is expressed by the authors as “gritty” if it felt like wet sand, “spongy” if it felt airy and had some spring like frosting, “gummy” if it felt like chewing gum and a little sticky, and “stiff/taffy” if it was dense and hard to compress like a soft caramel candy.

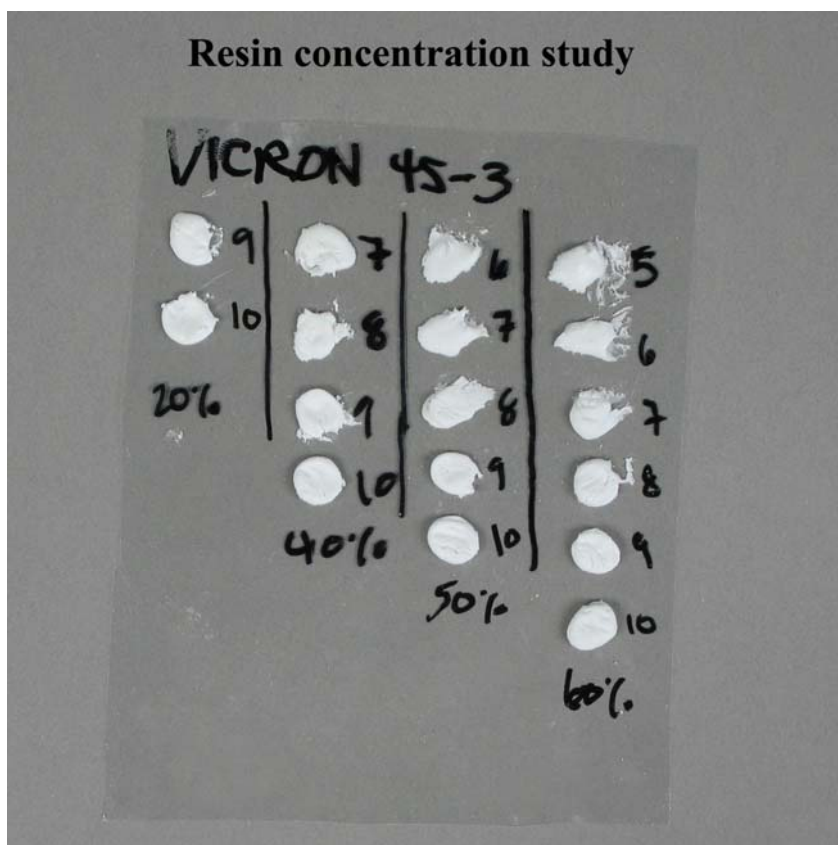


Figure 1. Testing the fillers at different concentrations.



The final recipes for the putties in this study are given in Table 1. The chosen recipe contained a filler to resin concentration that was  $\frac{1}{4}$  teaspoon below the identified threshold limit. The filler was mixed in 30 ml of 60% w/v B-72 in acetone and cast into three polycarbonate cups lightly coated with Vaseline petroleum jelly. For one of the three coupons, the bubbles that formed on the surface were filled using a spatula with a putty made from the same recipe. One set with a flat, even surface was required for the optical testing. Sanding the face of the filled coupons was done on rotating sanding wheels with Buehler sanding paper and micromesh to 12,000 grit. The face of the polished coupon was taped across one half and sandblasted to give a sample having the maximum obtainable gloss in addition to a matte surface. The final set of test coupons grouped by filler class is illustrated in Figure 2.

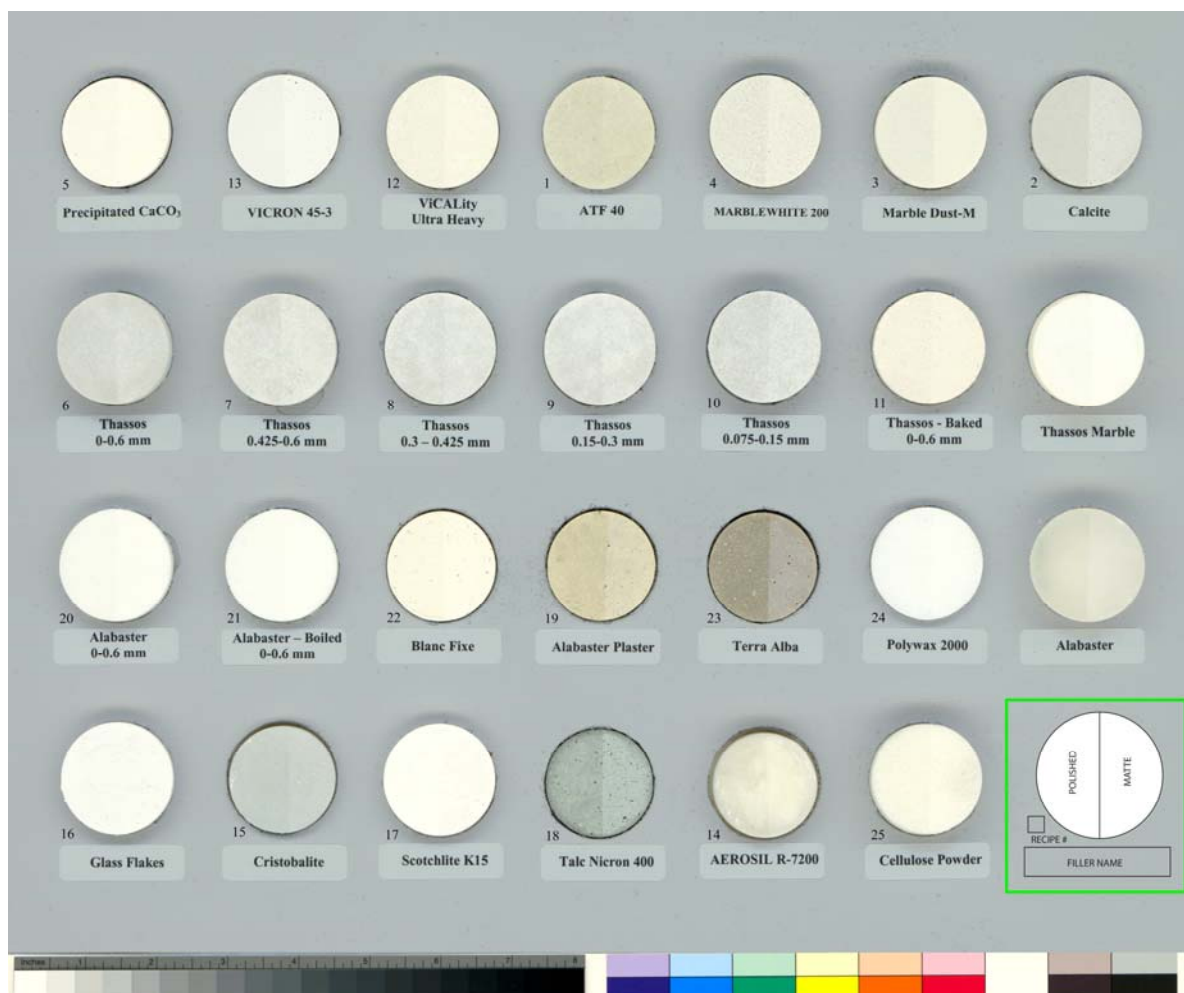


Figure 2. Final set of test coupons, grouped by class.

The only filler that had a slightly different preparation method was the Aerosil R-7200. An additional step was required to obtain a workable putty. Fumed silicas are difficult to use in acetone, and Degussa (2005) recommends using a product that is treated with a methacryloxy functional silane. The putty bulked with the R-7200 crumbled after drying as seen in Figure 3. This crumbled sample was ground in a coffee grinder to make a filler comprising both the resin and fumed silica. This ground up powder was then added to the regular 60% w/v B-72 mixture resulting in a stronger composite that did not break apart (Figure 4). While testing different fumed silicas, it became apparent that by using this two-step process, crushing the first bulked resin and adding it to more resin, it is possible to get more filler into the system without it fracturing. The authors feel that more testing needs to be done on fumed silica for this resin-solvent system in the future.



12.5 teaspoons Aerosil R-7200 mixed with 30 mL 60% w/v B-72 in acetone.

Figure 3. Putty bulked with Aerosil R-7200, showing crumbling after drying.



Two Phases:

12.5 teaspoons Aerosil R-7200 mixed with 30 mL 60% w/v B-72 in acetone. Dry putty crushed. Added to 30 mL B-72 in acetone with an additional 12.5 t. R-7200.

Figure 4. Putty shown in Fig. 3, after reconstitution using two-step process.

Since four of the fillers in this study are listed as California Prop 65 carcinogens, the Getty's safety officer, Scott Fife, monitored the air during sanding. The potentially carcinogenic fillers include ATF 40, cristobalite, talc, and VICRON 45-3 according to their MSDSs. Fife found that with the aid of a portable Nederman air extraction unit having a particulate filter, the dust levels were kept below the permissible limit of exposure. Any siliceous particle below 10 micron can travel to the alveoli of the lungs. The air was sampled using a Gilair 3 sampling pump set at 2.5 liters per minute, with a 37 mm, 5 micron PVC filter with an SKC aluminum cyclone attached. Analysis method was NIOSH 600 – Gravimetric and NIOSH 7500 – X-Ray Diffraction Spectroscopy for silica analysis. Broadspire/NATLSCO Risk and Safety Services conducted the analysis. The results for the permissible limit of exposure were concluded based on the specific sanding procedure carried out for this study.

### **About the fillers**

The final set of fillers includes a range of carbonates, silicates, sulfates, and cellulose powder. . The number of fillers tested was narrowed down to twenty-one, and are listed in Table 1 along with the recipe for the putty in a 60% w/v B-72 mixture. The collected properties for each filler and conclusions about the putty properties are listed in Table 2. The final set was chosen to include a range of types, fillers that are typically being used in the field of conservation, and ones with minimal processing and surface coating. At this time, not all of the properties of the dry fillers themselves have been determined, but eventually the properties will be added to Table 2 as the study progresses. Microscopy will be used to determine the particle shapes and refractive indices. X-ray diffraction was used by Giacomo Chiari, scientist at the Getty Conservation Institute, to confirm the composition of the purchased alabaster and Thassos marble samples.

John Larson published the use of crushed and boiled alabaster for marble filling, and it is a common choice among conservators (1978). The change in properties that occurs as a result of boiling is not exactly clear; however, it has been noted to change its hardness and translucency (Pullen 2004). Alabaster for this study was purchased from a local marble supplier and Giacomo Chiari used x-ray diffraction to confirm the composition as calcium sulfate. Pieces of the alabaster were boiled in water at 97 degrees Celsius for three hours. The alabaster then showed greater opacity and became notably softer to crush (Figure 5). Both boiled and unboiled alabaster was hand ground for comparison in the study, and even though there were slight differences in the properties of the dried putties, it was not significant enough to warrant making a major distinction. The boiled alabaster appeared to produce less overall surface gloss, a slight shift in color to a more yellow tone, and a slight increase in brightness. The hardness of the dried putty remained about the same.

A white marble from Thassos was purchased from a local supplier for hand grinding, and the stone was identified as calcium and magnesium carbonate using x-ray diffraction. Stephan Simon at GCI suggested baking the Thassos to modify its properties. Studies made by Malaga-Starzec indicate that “intergranular decohesion begins at temperatures between 40-50°C (104-122°F) for some marble types” due to thermal expansion and contractions – calcite more than



Figure 5. Test using crushed and boiled alabaster.

dolomite (Malaga-Starzec 2003, 306). The Thassos marble was baked for 12 hrs at 600 °C (1112°F) to force micro fracturing between the grains and increase its porosity (Figure 6). The measurements of surface hardness using Vickers showed that the baked marble became softer than the unbaked stone by a factor of two, making it noticeably easier to crush. In contrast, a dry coupon made with the baked Thassos appeared to be harder than the sample coupon with unbaked Thassos. This implies that baking (at least in the case of this marble) causes the marble itself to be softer, but not necessarily the dry putty. The baked Thassos stone became more opaque, and more yellow in tone, and this change in color and opacity was similarly reflected in its properties as a dried putty.

The hand crushed Thassos was sifted into six different groups having particle sizes between 0.075mm and 0.6mm to determine any measurable differences between them as bulking agents. The authors predicted that smaller particle sizes would generally give dried putties having higher gloss potential, harder, and an increased brightness. Unfortunately, the small study did not show any obvious pattern in property changes; the effect of particle size in bulking will require a more focused study in the future. All of the Thassos coupons gave similar fill results. All had a bluish tone, mottled surface, similar hardness, and fairly low gloss potential.



Figure 6. Test using baked Thassos marble.

### Visual Observations

The coupons were examined visually using the unaided eye before technical analyses to note shrinkage, surface appearance, surface bubbles, sandability, and carvability. Shrinkage is an important factor in workability, and a high shrinkage could cause compressive strain on the object being filled. The casting molds had a diameter of 2 cm, so the coupons were simply measured after they dried completely. Shrinkage was not an obvious problem with this set of putty mixtures, with the exception of Aerosil R-7200, which showed the greatest change. A small amount of shrinkage was noticed in the coupons with talc, calcite, Marbledust-M, and the sulfates. Cracking of the dried putty matrix can indicate a poor relationship between the resin-filler-solvent system. Cracking was found to be more common with the sulfate class, such as alabaster plaster, and terra alba. The carbonate Vicron 45-3 dried with a single crack across the middle. The coupons with blanc fixe and precipitated calcium carbonate dried with a wrinkled surface that seemed to be caused by the surface drying much faster than the center of the putty. A difference in homogeneity was noticed, as some of the putties dried with a mottled surface coloring, indicating flocculation of the particles. Mottled surfaces included the alabaster plaster, glass flakes, talc, Marblewhite 200, and ViCALity Ultra Heavy. The creation of bubbles was a problem with nearly all of the fillers. Fast evaporation of the solvent at the surface of the putty

inherently traps air bubbles. The three fillers showing the fewest bubbles respectively include the ViCALity Ultra Heavy, Vicron 45-3, and glass flakes. Two of the fillers, K15 Scotchlite and cellulose powder, were difficult to sand because they were so soft, and seemed to collect dirt and darken in the process.

## Hardness

A fill that is softer than the stone being repaired is one desirable characteristic. A Buehler Hardness testing instrument measuring Vickers (HV) was used at the Dental School of the University of California in Los Angeles. The instrument creates a 136° pyramidal mark with a diamond-tipped indenter onto the surface of the sample. The indentations were made at a range between 25-500 gram force (gf). The length of each diagonal line of the mark was measured using a graticle and a 40X oculus. Five measurements were taken across the face of each sample. The instrument calculates the HV dividing the force by the surface area of the indentation. Each coupon had a slightly different resistance to indentation and required different force settings. For example, the harder samples required higher force. Unfortunately, since all the coupons required micro forces below 500g, care must be taken when comparing HV results that were taken at different force ranges. Another complicating factor is the variation in hardness found across the surface of single coupons. It is most probable, that the range in particle sizes for some of the fillers causes the variation, therefore, the hardness of some putties can be rather inhomogeneous on a micro scale. At this time, a general summary of the result can be presented, however no overall data will be reported to prevent possible misinterpretation. In reality, conservators would not know the actual HV of the art material that requires filling, but this method should allow general categorization of the putties as hard, medium or soft by averaging the five HV results for each coupon. The fillers have been generally ranked in Table 4; however, the chart should only be considered a rough idea of the difference in hardness between the coupons.

One positive characteristic noted from comparing the putties and actual marble, is that most of the fillers produced putties that appear softer than the marble. Most of the fillers increased the hardness of 60% w/v B-72 in acetone, with the K15 glass microballoons, Aerosil R-7200, talc, cristobalite, blanc fixe, and precipitated calcium carbonate being probable exceptions. One aspect of the overall study that has not been carried out, includes drying times for all of the different putties. There is some concern by the authors, that even though all of the sample coupons were dried for one month, some of the fillers might prolong drying time, and give an abnormally low HV reading. This is another example of why the HV results cannot be fully interpreted at this time.

The fillers with larger particle sizes and wide particle size distribution show a greater range of HV across the surface. Comparatively, a sample of actual Thassos marble also shows a range of hardness across the surface. The surface hardness of the pure Thassos was compared with the baked Thassos sample and showed a reduction in hardness by an approximate factor of two after baking. In contrast, this was not necessarily true between the two putty coupons, as the pure and baked Thassos fillers gave similar hardness values to the dried putties. The boiled and unboiled pure alabaster samples also showed a reduced hardness by an approximate factor of two after

boiling. As with the marble, the pure and unboiled alabaster when used as a filler did not show any significant difference in hardness.

On a side note, no correlation was seen between the HV results and the actual carvability of the dried putty. Some of the fills were quite difficult to carve, including: all crushed Thassos, ATF 40, calcite, Marbledust-M, precipitated calcium carbonate, and cristobalite. Of these hard-to-carve putties, their HV values are random and ranged from HV2 to HV70. Though possessing a lower HV than actual marble, it appears that these values cannot be associated with practical information on carvability. None of the current test results have allowed reference for fillers giving putties that can be safely carved around a marble surface. Carvability is a characteristic that requires future attention.

## Optical Properties

One of the greatest challenges in matching a bulked resin to marble is that their optical properties are so inherently different. They reflect, transmit, refract, disperse and polarize light to varying degrees, making the analysis of these properties extremely complex. Preliminary work includes taking measurements of gloss, percent reflectance, and color. The results obtained thus far are encouraging, however a discrepancy between measured reflectance values and visual comparison indicate that more work needs to be done.

## Gloss

Gloss measurements were taken using a Nova-Color gloss meter borrowed from the Detroit Institute of Art's Conservation Department. The meter is capable of measuring surface reflectance at 20, 60, or 85 degrees. The measurements were given in gloss units (GU) where 100 is all specular light, as you would find in a perfect mirror. Low gloss units indicate diffuse reflection as on a matte surface. The meter was calibrated using a standard before measuring the coupons. All samples were polished to 12,000 grit. Three measurements were taken from each coupon, rotating it 90° for each reading at 20, 60, and 85 degrees. Rotating the sample was done in case there was a difference in gloss based on the direction of sanding, or small scratches. After averaging the results for each set of three measurements and ranking the fill coupons from matte to glossy, a slight difference in the order was noted at each reflectance angle. Table 4 ranks the GU from high to low for all of the samples at 60 degrees. (The ranking at this degree was comparable to the authors visual rankings in gloss using an unaided eye.)

Figure 7 shows the coupon set in a strong raking light to show the variation in surface gloss. In general, the carbonates and sulfates with small particle sizes obtained the most gloss—even higher than the polished pure Thassos marble. In contrast, fillers with larger particle sizes and wider particle size distributions such as the crushed Thassos and ATF 40 were at the lower end of the gloss scale and could not achieve as much polish as the pure Thassos. The sulfate class had a wide gloss range, whereby the blanc fixe obtained the highest polish and ground alabaster the lowest. The silicate group also had a wide gloss range with the K15 microballoons having the lowest polish of all the tested fillers, and the Aerosil R7200 being the silicate with highest polish.



The comparison of gloss units between the high polished coupons and actual marble can give us greater judgment in choosing an appropriate filler for putty-making. For example, as the hand ground Thassos coupons gave gloss units well below that of the pure Thassos sample, they might not be a good choice for the compensation of highly polished marble (at least, if used alone). Fillers with larger particle sizes and wider distribution also tended to obtain lower levels of gloss.

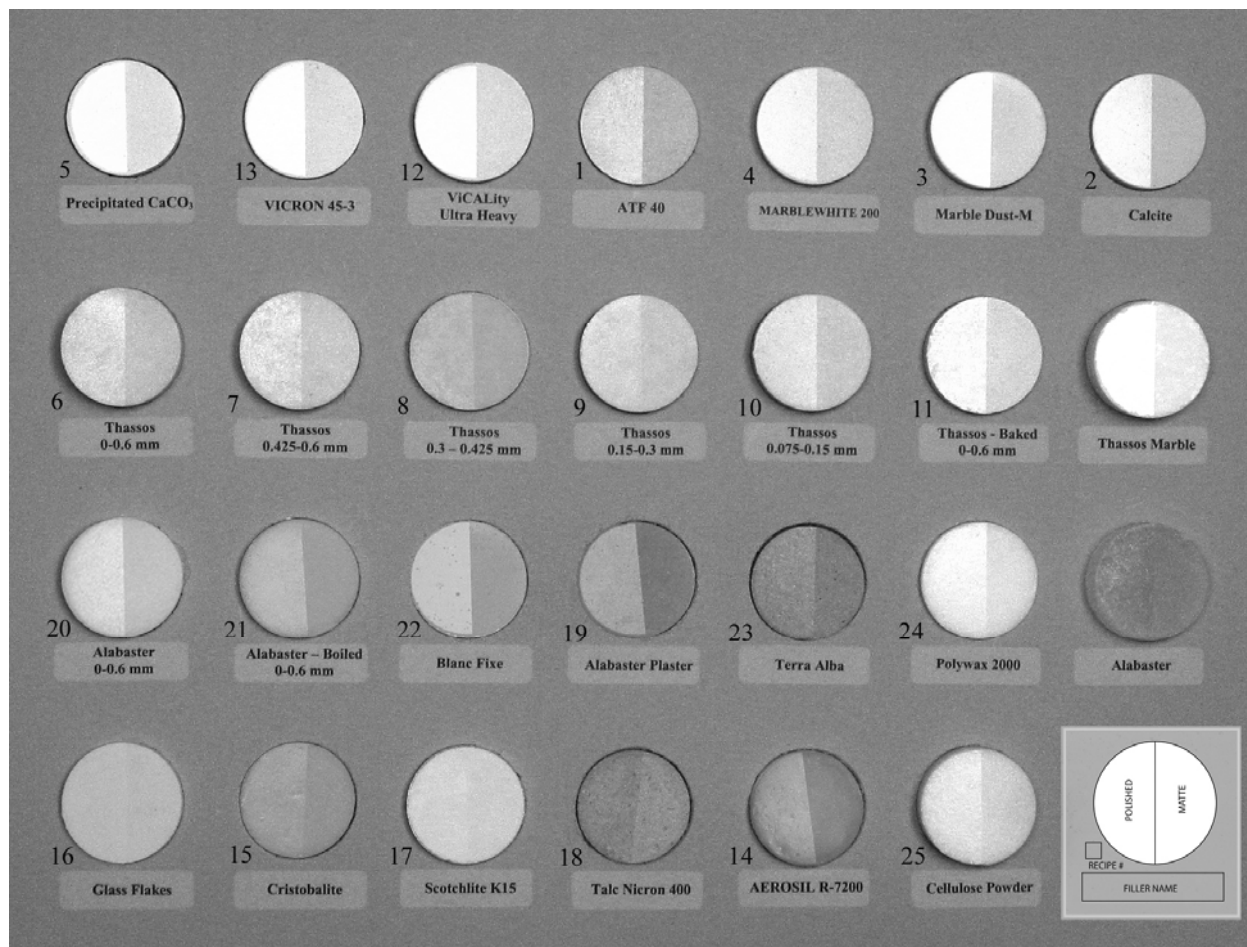


Figure 7. Coupons in raking light, to show differences in surface gloss.

## Reflectance and Color

The translucency was examined by Jim Druzik at the Getty Conservation Institute to compare the coupon samples with actual marble. Based on the theory that most light that is not absorbed into a surface is reflected, the % reflectance and  $L^*$  value for brightness was measured using a spectrophotometer at 550nm. Druzik applied an Ocean Optics spectrophotometer that uses a quartz halogen fiber optic system with a daylight 6500 K illuminant and 10 degree observer. The fillers are ranked from high to low brightness in Table 4. Based on reflectance values, about half

of the putties are brighter than the pure Thassos sample. The fillers giving the most similar value as the pure Thassos includes ground and boiled alabaster. The sulfates are around or brighter than the pure Thassos. The silicates have the greatest range in brightness and the lowest values, Cristobalite and AEROSIL R7200, giving them a more grayish appearance.

The  $L^*a^*b^*$  was used to compare the chromaticity between the coupons, whereby  $a^*$  is the redness-greenness coordinate and  $b^*$  is the yellowness-blueness coordinate. There is a wide range of  $a^*$  and  $b^*$  measurements amongst the coupons which should theoretically enable us to work with a wide palette. The most significant value of chromaticity for the filler coupons for matching actual marble seems to be the yellow-blue coordinate; therefore, the fillers have been ranked by their  $b^*$  values in Table 4.

Some preliminary tests were run on marble to see how the  $L^*a^*b^*$  values could be applied in practice. A sample piece of Carrara marble was measured using the same method as the coupons. The  $L^*a^*b^*$  values for Carrara did not exactly match the three values for any of the coupons. Focusing first on the  $L^*$  values, losses were chiseled out of the Carrara, and then filled with the two putty recipes having similar  $L^*$  values to the stone – cellulose powder and cristobalite. While both had similar values, the cellulose powder made a good match, yet the cristobalite did not. The boiled alabaster putty was chosen independently by the authors from the sample set using an unaided eye, and even though it had a very different  $L^*$  value as the Carrara, the visual match was very good. This study shows that  $L^*$  values alone cannot be used to match a marble.

Unlike a spectrophotometer, our eyes are trained to interpret the surface reflectance properties of materials in a psychological way, making the analytical results difficult to correlate with what we are actually seeing. With that challenge in hand, Jim is considering other reflectance techniques using an integrating sphere measurement geometry in order to correlate surface reflectance with total luminous transmittance for visual matching.

## Summary of Conclusions

Based on the result of this study, the set of twenty-one different putty recipes have been generally compared for hardness, gloss, color and brightness as shown in Table 4. The preliminary study to find an ideal resin concentration suggests using 60% w/v B-72 in acetone. The maximum amount of filler added to a fixed resin volume has been identified for each filler, which ranged considerably. The hardness values for all of the dried putties were below that of actual pure Thassos marble, however many of them were difficult to carve and may not be appropriate if a lot of finishing needs to be done on the fill. Differences in their working properties have been collected as well as general information about the filler properties (Table 2). The  $L^*a^*b^*$  values have allowed the fillers to be ranked by color and brightness, however cannot be directly correlated with the  $L^*a^*b^*$  values of actual marble. Half of the putties tested could not obtain a gloss as high as highly polished marble, which may affect the conservator's choice depending on the gloss of a sculpture requiring loss compensation.

This study should facilitate the conservator to fill marble losses that mimic the marble visually, and have appropriate physical properties. without the added need of inpainting. in a way that such knowledge of pigments improves the inpainting process. With the range of results, we

should be able to choose an appropriate putty for marble sculptures having varying compositions, condition, or age and without the need for inpainting. For an indoor, white marble in good condition, the fillers that appear to be the most useful in the palette of putties include alabaster powder and boiled alabaster powder due to their reflectance properties, relative softness, high gloss potential, tonality, and working properties. However, this is not to say that mixing fillers or other filler products not included in this study can also produce a good fill for loss compensation. The study is only considered a first phase of what could potentially be an extensive avenue of research.

### **Further Study**

The putties in this study are the beginning of a working palette of fills that would enable the conservator to fill marble losses that mimic the optical properties of marble, and have appropriate physical properties. A knowledge of the filler properties and how they effect B-72 will enable us to pick and choose, much like one would understand a pigment for inpainting. Future work on this phase of the project will include obtaining all the refractive indices of the fillers, and classifying their particle shape and size. Many, but not all of the fillers have been examined using laser granulometry by Assistant Scientist, David Carson, at the Getty Conservation Institute to determine their particle size distribution.

The great complexity involved in a bulked resin system demands a tremendous amount of work yet to be done. It would be beneficial to perform further study on drying rates of these putties. Long-term stability and reversibility of the fills still requires attention. Compressive testing would be useful to study for fills requiring structural strength. With the endless availability of industrial filler products, more filler types could also be compared. Industry has researched surface modifications, such as silanes, coupling agents, anti-skinning agents, as well as additives that improve filler performance. Looking at modified fillers may improve the workability and flexibility of the putty. Furthermore, the fillers could be studied in a different resin system, or even molten B-72 without the use of solvent.

### **Acknowledgements**

The authors wish to thank Brian Considine, Conservator in the Decorative Arts and Sculpture Conservation Department at The J. Paul Getty Museum for his support, as well as numerous other staff at the Museum: Mark Mitton, George Johnson, Jane Bassett, Arlen Heginbotham, Jessica Berman, Scott Fife, and Eric Risser. Dave Carson, Project Scientist at the Getty Conservation Institute has been carrying out all the work on laser granulometry. Jim Druzik, Senior Scientist at the Getty Conservation Institute, developed the translucency and color testing method. Support from the other scientists at the GCI include Giacomo Chiari, Karen Trentleman, Julie Arslanoglu, Crystal Pesme, and Ron Schmitling. Valerie Greathouse at the Getty Research Institute assisted with the literature searches on fillers and B-72. Dr. Eric Sung, Professor at the UCLA Dental School instructed and guided us in the use of their Hardness Testing instrument. The Detroit Institute of Arts, for the loan of their Nova-Gloss Meter for this project.

## **Instruments**

Vickers Hardness Testing Instrument, 40X oculus, 25-500 gram force, Buehler Ltd, 41 Waukegan Rd, Lake Bluff, IL 60044, 847-295-4542

Gloss Meter, Statistical Novo-Gloss, Macbeth Statistical Novogloss

Grinder, MF10 basic, IKA Labortechnik, set at 3000 rpm/min for grinding Thassos marble and alabaster.

Thermolyne Furnace 1400 for baking the Thassos marble.

Paasche Air Eraser Kit, used at 15 psi with medium grit pumice.

## **Suppliers**

Alabaster, Thassos marble, Cararra marble:

Carnivalel and Lohr, Inc., 6251 Clara Street, Bell Gardens, CA 90201, (562) 927-8311

Marblewhite 200, ViCALity Ultra Heavy, Vicron 45-3, ATF 40:

Specialty Minerals, 260 Colombia Street, Adams, MA 01220, (413) 743-0591

Blanc fixe, terra alba, cristobalite, glass flakes, marbledust-M: very fine, calcite, kaolin, alabaster plaster:

Kremer Pigments Inc., 228 Elizabeth Street, New York, NY 10012, (212) 219-2394

Precipitated calcium carbonate, Polywax 2000, Acryloid B-72:

Conservation Support Systems, 924 West Pedregosa Street, Santa Barbara, CA 93101, (805) 682-9843

Pumice (medium):

Conservation Materials (now Conservator's Emporium), 385 Bridgepoint Drive, South St. Paul, Minnesota 55075-2466, (800) 672-1107, fax (651)554-9217

Whatman ashless cellulose powder:

Thomas Scientific, P.O. Box 99, Swedesboro, NJ 08085, (800) 345-2100

Talc: Nicron 400:

TAP Plastics Inc., Dublin, CA 94568, (800) 246-5055, ([www.tapplastics.com](http://www.tapplastics.com))

Acematt OK 520, Aerosil COK 84, Aerosil R972, Aerosil R-7200:

Degussa Corporation, 379 Interpace Parkway, Parsippany, NJ 07052, (973) 541-8040

K15 Scotchlite glass bubbles, S22 Scotchlite glass bubbles:  
3M, 3M Center, St. Paul, MN 55144-1000, (651) 737-6501

Vaseline petroleum jelly:  
Tyco Healthcare/Kendall, 15 Hampshire St., Mansfield, MA 02048

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Recipe #	Filler	(mL)
	<b>Carbonates</b>	
1	ATF 40	27.5
2	Calcite	35
3	Marbledust-M, very fine	45
4	Marblewhite 200	40
5	Ppt. CaCO <sub>3</sub>	35
6	Thassos marble - ground (<0.6mm)	40
7	Thassos marble - ground (0.425-0.6mm)	40
8	Thassos marble - ground (0.3-0.425mm)	35
9	Thassos marble - ground (0.15-0.3mm)	35
10	Thassos marble - ground (0.075-0.15mm)	37.5
11	Thassos Marble - baked (<0.6mm)	25
12	ViCALity Ultra Heavy	37.5
13	Vicron 45-3	47.5
	<b>Silicates</b>	
14	Aerosil R-7200	62.5
15	Cristobalite	32.5
16	Glass Flakes	50
17	K15 Scotchlite Glass Bubbles	42.5
18	Talc: Nicron 400	35
	<b>Sulfates</b>	
19	Alabaster plaster	32.5
20	Alabaster ground (<0.6mm)	42.5
21	Alabaster boiled (<0.6mm)	42.5
22	Blanc fixe	32.5
23	Terra Alba	32.5
	<b>Other</b>	
24	Polywax 2000	32.5
25	Whatman Ashless Cellulose Powder	22.5

Table 1. Putty Recipes. The chart shows the amount of filler added to 30mL of 60% w/v Acryloid B-72 in acetone. Each putty recipe is numbered for reference throughout the paper, as all properties and observations are only applicable to this particular ratio of concentrations. If modifications were made to the resin-solvent concentrations, or filler-resin concentrations, the properties would inevitably change.

Table 2. Filler and putty properties.

Filler Composition Supplier	Filler Information health	Putty Observations	Recipe #
ATF 40 96% $\text{CaCO}_3$ 1% $\text{MgCO}_3$ <0.2% $\text{H}_2\text{O}$ Specialty Minerals	ATF limestone products are characterized as having high purity, and controlled brightness, particle size and density. This product line is used in tile/sheet flooring, roofing and other building products (Specialty Minerals). Particle size: 0.07 - 0.15 mm (Specialty Minerals) Particle shape: random, crushed (Specialty Minerals) CA Prop 95 carcinogen	-wet putty has a gritty texture -yellowish, mottled surface coloration -has small black inclusions -low polish obtainable (uneven) -hard carvability -high hardness -numerous air bubbles	1
Calcite $\text{CaCO}_3$ Kremer (58720)	Calcite can have more than 300 crystal shapes but is generally an irregular, low surface area particle (Katz). It is formed by the crystallization of $\text{CaCO}_3$ below 30°C, and occurs in limestone, marble, and chalk (Solomon). Some manufacturers pretreat the surface with carboxylic acids to make it hydrophobic and neutralize its pH (Solomon). (No surface analysis of the Kremer product has been done at the time of this paper.) Particle size: undetermined as of date	-wet putty has a gummy texture -high polish obtainable -hard carvability -high hardness -numerous air bubbles	2
Marble dust-M, very fine Natural $\text{CaCO}_3$ Kremer (59600)	Ground, natural calcium carbonate Particle size: 0-0.6 mm (MSDS)	-wet putty has a gummy texture -high polish obtainable -hard carvability -high hardness -numerous air bubbles	3
MARBLEWHITE 200 96% $\text{CaCO}_3$ , 1% $\text{MgCO}_3$ , <0.1% $\text{Fe}_2\text{O}_3$ , <0.1% $\text{H}_2\text{O}$ Specialty Minerals	Milled, natural calcite ore that the manufacture processes for greater brightness, and controlled particle size. Particle size: 0.045 - 0.074 mm (Specialty Minerals)	-wet putty has a gummy texture -medium carvability -high polish obtainable -high hardness -numerous air bubbles (hard to fill them)	4

Precipitated Calcium Carbonate $\text{CaCO}_3$ Conservation Support Systems	Precipitated calcium carbonates have greater brightness, smaller particles size, greater purity, and higher gloss in resins than natural $\text{CaCO}_3$ (Gachter). Particle size: around 0.04 mm	-wet putty has a gummy texture -hard carvability (brittle) -high polish obtainable -low hardness -numerous air bubbles -coupon dried with wrinkled surface	5
Thassos marble $\text{CaCO}_3$ $\text{CaMg}(\text{CO}_3)_2$ Carnivalel & Lohr	Calcium and magnesium carbonate composition was determined at GCI using XRD. Crushed, and sieved. Particle size: <0.6 mm	-wet putty has a gritty texture -hard carvability -low polish (uneven) -high hardness -numerous air bubbles	6
Thassos marble $\text{CaCO}_3$ $\text{CaMg}(\text{CO}_3)_2$ Carnivalel & Lohr	Calcium and magnesium carbonate composition was determined at GCI using XRD. Crushed, and sieved. Particle size: 0.425-0.6 mm	-wet putty has a gritty texture -hard carvability -low polish obtainable (uneven) -high hardness -numerous air bubbles	7
Thassos marble $\text{CaCO}_3$ $\text{CaMg}(\text{CO}_3)_2$ Carnivalel & Lohr	Calcium and magnesium carbonate composition was determined at GCI using XRD. Crushed, and sieved. Particle size: 0.300 - 0.425 micron	-wet putty has a gritty texture -hard carvability -low polish obtainable (uneven) -high hardness -numerous air bubbles	8
Thassos marble $\text{CaCO}_3$ $\text{CaMg}(\text{CO}_3)_2$ Carnivalel & Lohr	Calcium and magnesium carbonate composition was determined at GCI using XRD. Crushed, and sieved. Particle size: 0.150 - 0.300 mm	-wet putty has a gritty texture -hard carvability -low polish obtainable (uneven) -high hardness -numerous air bubbles	9
Thassos marble $\text{CaCO}_3$ $\text{CaMg}(\text{CO}_3)_2$ Carnivalel & Lohr	Calcium and magnesium carbonate composition was determined at GCI using XRD. Crushed, and sieved. Particle size: 0.075 - 0.150 mm	-wet putty has a gritty texture -hard carvability -low polish obtainable -high hardness -numerous air bubbles	10
Thassos marble – baked $\text{CaCO}_3$ $\text{CaMg}(\text{CO}_3)_2$ Carnivalel & Lohr	Calcium and magnesium carbonate composition was determined at GCI using XRD before baking. Chunks of marble were baked for 12 hours at 600°C. Crushed, and sieved. Particle size: <0.6 mm	-wet putty has a gritty texture -hard carvability -low polish obtainable -high hardness -numerous air bubbles	11

ViCALity Ultra Heavy PCC 60-100% $\text{CaCO}_3$ <0.2% $\text{H}_2\text{O}$ Specialty Minerals	ViCALity Ultra Heavy PCC is a calcitic, precipitated calcium carbonate. Particles have a semi-regular prismatic shape (Specialty Minerals). Particle size: 0.012 mm (Specialty Minerals)	-wet putty has a gummy texture -medium-soft carvability -high polish obtainable -medium hardness -very few air bubbles	12
Vicron 45-3 97% $\text{CaCO}_3$ 0.5% $\text{MgCO}_3$ <0.1% $\text{Fe}_2\text{O}_3$ <0.2% water Specialty Minerals	From natural limestone high in calcium having a controlled particle size and low surface area (Specialty Minerals). Particle size: 0.010 mm average (Specialty Minerals) CA Prop 95 carcinogen	-wet putty has a gummy texture -medium-soft carvability -high polish obtainable -medium hardness -few air bubbles -dry coupon cracked at center	13
Aerosil R-7200 $\text{SiO}_2$ Degussa	Hydrophobic fumed silica coated with methacryloxy functional silane (2-Propenoic acid, 2-methyl-,3-(trimethoxysilyl) propylester). Degussa recommended this product for higher loading levels, and better miscibility in acetone systems. Particle size: 12 nm avg. (Degussa)	-wet putty has a stiff/taffy texture -medium carvability (brittle) -high polish obtainable -soft hardness -numerous air bubbles	14
Cristobalite, very fine $\text{SiO}_2$ Kremer (58689)	Quartz combined with cristobalite and tridymite which are high-temperature polymorphs of quartz commonly found in volcanic rocks. Particle size: 0.008 mm CA Prop 95 carcinogen	-wet putty has a gummy texture -hard carvability -high polish obtainable -soft hardness -numerous air bubbles	15
Glass Flakes $\text{SiO}_2$ Kremer (ZK59852)	Composed of oxides of silicon, aluminum, calcium, boron, and magnesium in an amorphous state. Particle size: unknown as of date	-wet putty has a gummy texture -medium carvability -medium polish obtainable -high hardness -numerous air bubbles	16
K15 Scotchlite Glass Bubbles 97-100% Soda lime borosilicate glass 3% $\text{SiO}_2$ , amorphous 3M	3M bubbles are produced by passing glass particles containing a blowing agent, through a flame. Hollow spheres. Particle size: 0.030 – 0.105 mm	-wet putty has a spongy texture -very soft carvability -low polish obtainable -low hardness -numerous air bubbles -hard to sand – too soft, pores trap grit	17

Talc: Nicron 400 Powder $\text{MgO} \cdot 4\text{SiO}_2 \cdot \text{H}_2\text{O}$ TAP Plastics	An asbestos-free, hydrated magnesium silicate. Particle size: unknown as of date CA Prop 95 carcinogen	-wet putty has a gummy/stiff texture -soft carvability -low polish obtainable -low hardness -numerous air bubbles (hard to fill them)	18
Alabaster Plaster $\text{CaH}_4\text{O}_6\text{S}$ Kremer (58340)	Calcium sulfate dihydrate, obtained by grinding and separating gypsum that contains about 20% water of crystallization. Particle size: unknown as of date	-wet putty has a gummy texture -soft carvability -high polish obtainable -medium hardness -numerous air bubbles (hard to fill them) -dry coupon had numerous cracks	19
Alabaster, ground $\text{CaSO}_4$ Carnivalel and Lohr	Calcium sulfate composition confirmed at GCI using XRD. Crushed and sieved. Particle size: <0.6 mm	-wet putty has a gritty texture -soft carvability -medium polish obtainable -medium hardness -numerous air bubbles	20
Alabaster, boiled $\text{CaSO}_4$ Carnivalel and Lohr	Calcium sulfate composition confirmed before boiling using XRD at GCI. Larson recommends heating water-soaked alabaster to increase whiteness before crushing it into powder (1978). Crushed and sieved. Particle size: <0.6 mm	-wet putty has a gritty texture -soft carvability -medium polish obtainable -medium hardness -numerous air bubbles	21
Blanc Fixe $\text{BaSO}_4$ Kremer (58700)	Obtained from purified barite having a definite particle size by precipitation (Katz 1978). Particle size: <0.8 mm	-wet putty has a gummy texture -medium carvability -high polish obtainable -low hardness -numerous air bubbles (hard to fill them) -coupon dried with wrinkled surface	22

<p>Terra Alba  <math>\text{CaSO}_4 \cdot 2\text{H}_2\text{O}</math>            Kremer (58300)</p>	<p>A fully hydrated calcium sulfate or natural gypsum, selenite.            Particle size: 0.001–0.07 mm</p>	<p>-wet putty has a gummy texture            -medium-soft carvability            -medium polish obtainable            -high hardness            -numerous air bubbles (hard to fill them)            -dry coupon had numerous cracks</p>	<p>23</p>
<p>Polywax 2000  <math>-\text{[CH}_2\text{-CH}_2\text{]}_n</math>            Conservation Support Systems</p>	<p>Polyethylene (Ethene homopolymer) thoroughly ground in a Krupps coffee grinder. Melting point 126°C/259°F (MSDS).            Particle size: unknown at this time</p>	<p>-wet putty has a gritty texture            -soft carvability (brittle)            -medium polish obtainable (uneven)            -medium hardness            -numerous air bubbles</p>	<p>24</p>
<p>Whatman ashless cellulose powder  <math>\text{C}_6\text{H}_{10}\text{O}_5</math>            Thomas Scientific</p>	<p>Long chain molecules of cellulose.</p>	<p>-wet putty has a spongy texture            -medium-soft carvability            -medium polish obtainable            -low hardness            -numerous air bubbles            -hard to sand, too soft, gets dirty</p>	<p>25</p>



Table 3. List of fillers tested and dropped from study.

Note: These fillers were mostly eliminated because of the need to limit the scope of the project, or difficult working properties.

Filler Composition Supplier	<u>Comments</u>
ATF 20 96% CaCO <sub>3</sub> , 1% MgCO <sub>3</sub> Specialty Minerals	<u>ATF 20 has mostly 50 micron particles with less distribution than the ATF 40. Both are a light gray color and have black impurities. Both products appear very similar.</u>
ViCALity Heavy PCC CaCO <sub>3</sub> Specialty Minerals	This product was dropped because it was similar to other fillers in the final list, such as precipitated calcium carbonate from Conservation Support Systems.
ViCALity Extra Light PCC CaCO <sub>3</sub> Specialty Minerals	The product description says it has a 1.6-1.8 micron scalenohedral particle. It has the lowest density of this product line. It appeared too bright and opaque for this particular study.
Kaolin H <sub>2</sub> Al <sub>2</sub> Si <sub>2</sub> O <sub>8</sub> .H <sub>2</sub> O Kremer (5925)	Hydrated aluminum-silicate clay. The fill was too highly colored for this study.
Milled Glass Fibers, E-Glass Fibers – Short SiO <sub>2</sub> TAP Plastics	A continuous filament glass having milled fibers. Samples were dark grey, and difficult to mix into the 60% w/v B-72.
Mountain Crystal SiO <sub>2</sub> , Kremer (11401)	A quartz powder. Too expensive for wide use. CA Prop 95 carcinogen
S22 Scotchlite Glass Bubbles SiO <sub>2</sub> , 3M	The K15 and S22 were very similar in B-72, and since the K15 is used in industry more often, and less expensive, the S22 was eliminated.
Visco-Fill II: Micro Fine Precipitated Silica SiO <sub>2</sub> TAP Plastics	The test putties had numerous bubbles and are very translucent. They were similar to the fumed silica's. Samples tended to crumble.
ACEMAT OK 520	Chemically prepared, precipitated silica manufactured as a matting agent and wax coated. More translucent

SiO <sub>2</sub> Degussa	fills achieved at higher resin concentrations, while opaque at lower resin concentrations. (Perhaps the higher solvent content dissolves the coating?) Coated fillers were avoided in this study.
AEROSIL COK 84 82-86% SiO <sub>2</sub> , 14-18% Al <sub>2</sub> O <sub>3</sub> Degussa	A mixture of hydrophilic fumed silica and highly dispersed aluminum oxide in the ratio of 5:1. Samples tended to crumble, and the composition too complicated for this study.
AEROSIL R 972 >99.8% SiO <sub>2</sub> Degussa	A hydrophobic fumed silica coated with dimethyldichlorosilane. Limited concentration of filler could be added to the B-72 without it crumbling, making it too translucent.
CAB-O-SIL 99.8% SiO <sub>2</sub> Degussa	Hydrophilic fumed silica. Tested putties tended to crumble easily.
Fumed Silica SiO <sub>2</sub> Conservation Support Systems	Tested putties tended to crumble easily.
SULFATES	
Calcium sulfate hemihydrate CaSO <sub>4</sub> ·1/2H <sub>2</sub> O unknown source	Test putties were slow to dry, and highly colored for this particular study
Calcium Sulfate CaO <sub>4</sub> S unknown source	Test putties were slow to dry, and highly colored for this particular study.
Marienglas gypseous spar extra fine natural mineral (MSDS) Kremer (11810)	Too expensive for frequent use.

Table 4. Fillers ranked by different properties

Gloss	Hardness	Color b* (Polished)	Brightness L* (Polished)
HIGH GLOSS	SOFT	BLUE	LOW
<u>Blanc Fixe</u>	Aerosil R-7200	Cristobalite	Pure Alabaster
Marbledust-M	K15	Polywax 2000	Aerosil R-7200
Vicron 45-3	Ppt. CaCO <sub>3</sub>	Pure Thassos	Cristobalite
Calcite	Cristobalite	Cellulose Powder	Pure Carrara
Marblewhite 200	Blanc Fixe	Thassos 0.425-0.6 mm	Terra Alba
Alabaster plaster	Talc	Thassos <0.6 mm	Cellulose Powder
ViCALity Ultra Heavy	Cellulose Powder	Ground Alabaster	Polywax 2000
Ppt. CaCO <sub>3</sub>	B72	Thassos 0.15-0.3 mm	Talc Nicron 400
Aerosil R-7200	Polywax 2000	Boiled Alabaster	ATF 40
Cellulose Powder	Ground Alabaster	Thassos 0.3-0.425 mm	Thassos <0.6 mm
Ground Alabaster	Boiled Alabaster	Thassos 0.075-0.15 mm	Ground Alabaster
Polywax 2000	Vicron 45-3	Aerosil R-7200	Pure Thassos
Pure Thassos	Glass Flakes	K15	Boiled Alabaster
Boiled Alabaster	Alabaster plaster	Talc Nicron 400	Thassos 0.425-0.6 mm
Terra Alba	ViCALity Ultra Heavy	Glass Flakes	Thassos 0.3-0.425 mm
Thassos 0.075-0.15mm	Marblewhite 200	Vicron 45-3	Thassos 0.15-0.3 mm
Cristobalite	Terra Alba	Calcite	Thassos 0.075-0.15 mm
Baked Thassos	Pure Boiled Alabaster	Baked Thassos	Marbledust-M
ATF 40	Thassos 0.075-0.15 mm	Ppt. CaCO <sub>3</sub>	Calcite
Talc Nicron 400	Thassos 0.425-0.6 mm	Marbledust-M	Alabaster plaster
Glass Flakes	Thassos 0.15-0.3 mm	Blanc Fixe	Marblewhite 200
Pure Alabaster	Thassos <0.6 mm	Pure Alabaster	Blanc fixe
Thassos <0.6 mm	Marbledust-M	ATF 40	Vicron 45-3
Thassos 0.425-0.6 mm	Calcite	Marblewhite 200	Glass Flakes
Thassos 0.15-0.3 mm	ATF 40	ViCALity Ultra Heavy	Baked Thassos
Thassos 0.3-0.425 mm	Pure Alabaster	Terra Alba	Ppt. CaCO <sub>3</sub>
K15	Thassos 0.3-0.425 mm	Alabaster Plaster	ViCALity Ultra Heavy
	Baked Thassos		K15
	Pure Baked Thassos		

Pure Thassos

LOW GLOSS

HARD

YELLOW

HIGH

## LOSS COMPENSATION ON A MICHUACAN INLAID LACQUER TRAY USING PIGMENTED ACRYLOID B72 FILM

Paula Hobart, Mina Thompson, Maureen Russell

### Abstract/Introduction

This paper illustrates an interesting loss compensation technique for a Mexican Michoacan wooden lacquer tray owned by the Museum of International Folk Art (MOIFA) in Santa Fe, NM (Fig.1). The tray dates to the 1920s and was made using the traditional inlaid technique called *embutida* or *incrustada*. The tray had a large loss in the lacquer layer along the rim. A footprint of the original inlaid design was visible in the area of loss due to staining of the wooden substrate from the original lacquer. Pigmented Acryloid B-72 in acetone was cast in thin films and cut to fit the inlaid design in the area of loss. This type of loss compensation simulates the traditional Michoacan inlaid technique by using the visible design pattern in the wooden substrate. Traditional gap-filling materials and methods were less suitable for this particular object due to the thinness of the loss and the desire to make use of the visible design pattern in the substrate. Advantages of this technique include minimal intervention and a dry fill material with no residues to penetrate into the substrate, producing an easily reversible fill. This loss compensation technique can be applied to other materials with similar requirements.



Figure 1. Michoacan Inlaid lacquer tray, ca.1920's, courtesy Museum of International Folk Art, Santa Fe, New Mexico, acc. No. A.78, 42-5.

## Traditional Michoacan Inlaid Technique

### Traditional Materials:

- *Aje*: a wormlike insect used to produce an oily waxy substance. The *aje* insects are dropped in boiling water until completely disintegrated into a gelatinous substance that is strained, rinsed in cold water and dried to form a solid mass. The *aje* is mixed with *chia* oil and powdered dolomite to produce the size or *sisá*, which is the basis of the lacquer.
- *Chia*: oil extracted from the seed of a wild sage, *salvia chian*. Chia oil is a principal ingredient in the size mixed with *aje* oil and powdered dolomite.
- Powdered dolomite: a brittle mineral containing calcium and magnesium carbonate plentiful around Michoacan.
- Ground earth pigments mixed with the size.

**Step 1:** The wooden *batae* (tray) is shaped by scraping the inside. Woods that have little natural resin are used because they readily absorb the oils.

**Step 2:** The base/background color is built up in layers by successive applications (approx. six coats) of size and powdered pigments applied with the fingers and rubbed with the palm of the hand. The base coat is then allowed to cure for 3 or 4 days.

**Step 3:** The design for the next color is incised in the base coat of lacquer and peeled away to reveal the underlying wood.

**Step 4:** For the next color, size and powdered pigments are mixed together and built up using the same technique as the base coat until the design area is level with the background. The tray is set aside to dry for 3 or 4 days. Step 2 and 3 are repeated for each additional color.



Figure 7. Detail of tray owned by Museum of International Folk Art in raking light, showing characteristic raised edges of inlaid technique.



**Casting B-72: Film Recipe and Method (Fig. 8-13)**

Figure 8. Dry powdered pigments are used to tone the resin to match the area of loss. The pigments should be mulled before mixing to produce a homogenous film. A small amount of xylene is used to wet the dry pigments for mulling. After mulling, the pigment and xylene paste is mixed with 50% B-72 in acetone (w/v).



Figure 9. Unsuccessful film with air bubbles



Figure 10. After casting many unsuccessful films with air bubbles, the authors consulted Stephen Koob, who recommended casting the pigmented resin on a polyethylene substrate and covering for the first 24 hours to restrict but not prevent solvent evaporation. A plastic bag works well as long as supports are used to prevent the top of the bag from touching the B-72 film. The enclosed air space creates a xylenes vapor chamber that prevents skin formation on the surface of the B-72 film during curing (Koob, 2005).

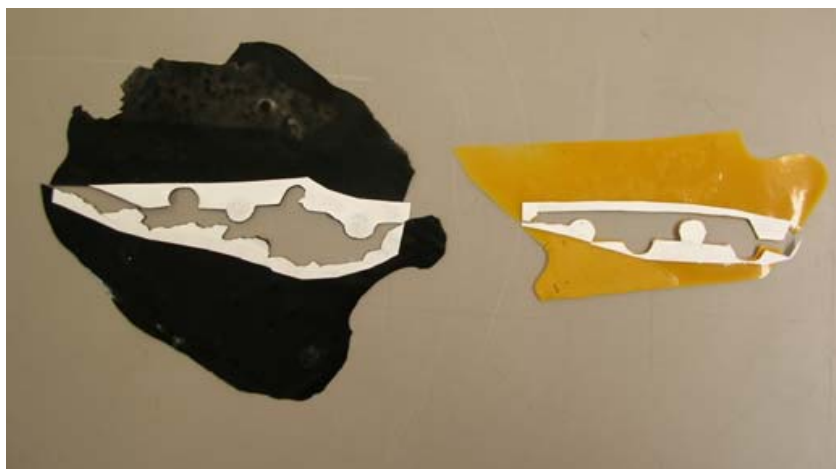


Figure 11. The area of loss on the object is traced through a sheet of Mylar. A Xeroxed copy of the Mylar tracing is attached to the B-72 film using acetone, and the shape of the loss is cut from the film using fine scissors. The working properties for cutting and shaping are best between 2-4 days after casting. The film is too flexible for cutting before 2 days and too brittle after 4 days.



Figure 12. Final shape of B-72 film



Figure 13. The cut-out sections are fused together, their surfaces smoothed, and the film thinned using a heated spatula between sheets of silicone release Mylar.

### Before Treatment

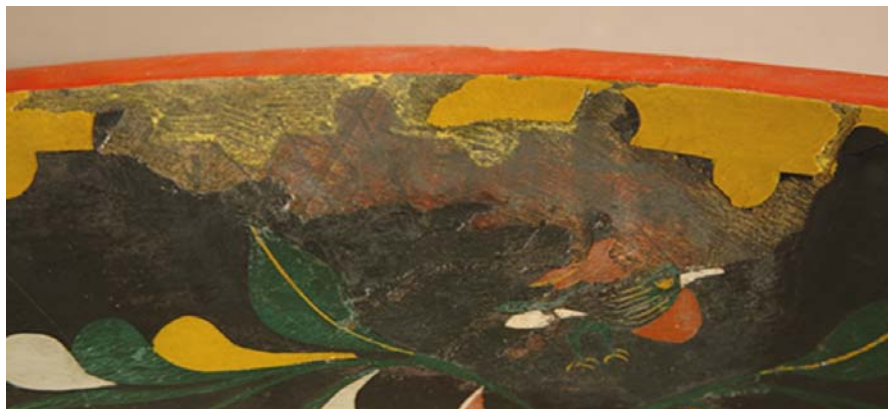


Figure 14. Shallow loss along the rim edge approximately 5" wide. Considerations in loss compensation included reversibility, visual integration while remaining visible as a repair and flexibility with regard to adhesion of the fill material to accommodate any expansion and contraction of the wood.

### During Treatment

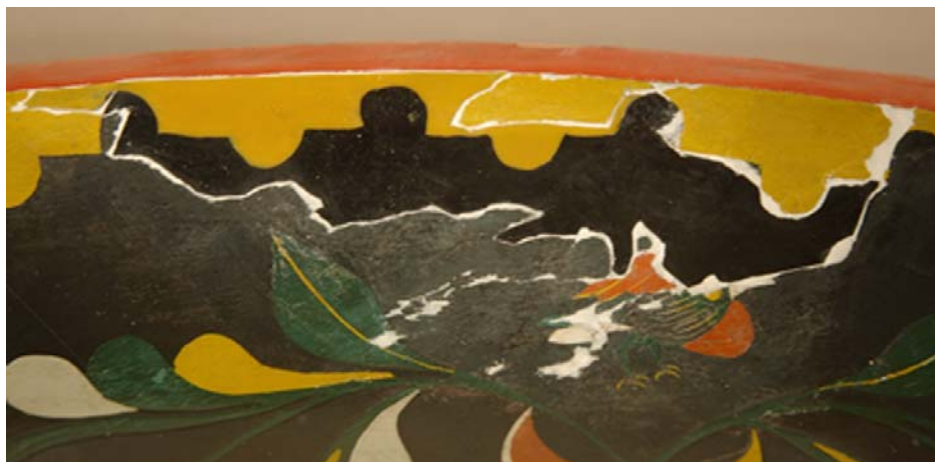


Figure 15. The pigmented B-72 film is attached in the area of loss using an acetone cotton swab to make the back of the film tacky and then pressing into place. The adhesion of the film to the substrate is weak but secure. Once the film is in place, final filling can be done in the small spaces and gaps around the film using a commercial gap-filling material such as Dap vinyl spackling paste or Polyfix (calcium carbonate in PVOH binder) and inpainting to visually integrate.

## After Treatment



Figure 16. Pigmented B-72 film is a non-invasive, easily reversible treatment approach that remains visible as a repair while integrating visually with the surrounding area.

## Suppliers

Dry powdered pigments

Conservation Materials Ltd., 340 Freeport Blvd., Sparks, NV 89431

Acryloid (Paraloid) B-72: ethyl methacrylate copolymer in a 50% solution in acetone

Polyfix, (calcium carbonate in PVOH binder)

Conservation Support Systems, P.O. Box 91746, Santa Barbara, CA 93190, (805) 682-9843.

DAP vinyl spackling (proprietary vinyl spackling compound)

DAP, Inc. Dayton, OH 45401; widely available in hardware stores.

Silicone coated polyester film (Mylar)

University Products, Inc. 517 Main Street, P.O. Box 101 Holyoke, MA 01041-0101, (800) 628-1912.

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