Objects Specialty Group Postprints

Volume Three

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Objects Specialty Group Postprints

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FOREWORD

The third volume of *Postprints* to be published by the Objects Specialty Group consists of the papers presented during three differing sessions from the OSG session of the 1995 AIC Annual Meeting in St. Paul. The topics chosen for the OSG session included: structural treatments, the desalination of ceramics, and new materials and techniques.

All fourteen of the presentations delivered in St. Paul are represented in this publication. The paper scheduled to be given by Terri Schindel was not presented and is not included in this volume. The papers are organized in the order in which they were given at the 23rd Annual Meeting. Both ethical and logistical problems were addressed regarding the structural treatment of materials as diverse as leather, reed, bronze and stone. Papers dealing with the desalination of ceramics focussed on the practical, the theoretical and the experimental issues involved in desalination. The afternoon session, intended to be less formal than the morning, included a wide range of short presentations in which I hoped to provide an opportunity for people to share ideas and materials used in their treatments without the necessity of preparing a formal paper. These presentations varied in the degree of formality; this is reflected in the length and style of the papers included in the *Postprints*.

I would like to thank Virginia Greene for her exhaustive and dedicated work on formatting and editing this volume. The OSG *Postprints* is a non-juried compilation. Only minor editing was done by the compilers. Authors are encouraged to submit papers presented here for publication in the *Journal of the American Institute for Conservation*, or in other juried publications.

Julie Lauffenburger
OSG Chair

February 1996

THREE CHAIRS FOR LEATHER CONSERVATION

Brian R. Howard and April H. Berry

INTRODUCTION

This paper was the result of a grant application rejection, and the subsequent reapplication and approval for the treatment of a 17th century leather upholstered armchair.

The initial application appears to have been denied as the result of confusion over the use and function of the chair after treatment: was it to be used as a study and research artifact in its current unstable and deteriorated condition, or as an object functioning as an interpretive component in a historical setting?

Initial comments by the reviewing committee suggested that the original treatment proposal was too extreme, and that a more current, less invasive treatment option should be explored. These comments were based on the assumption that the chair would be placed in a study collection. If this were the case, the original treatment procedures were deemed inappropriate. It is important to note that with the addition of a statement concerning intended use, the treatment proposal was accepted as originally written. This points to the need for clarification of treatment options and the rationale for selection of specific treatments.

The grant writing process led us to reconsider the necessary factors required to evaluate an appropriate course of action for the treatment of artifacts in severely deteriorated condition. Several of the factors used in the determination of treatment choice are listed below. Certainly there may be other factors involved as well, but for the following situations these were the most important considerations. Please note that these are not in any prioritized order.

Condition of the artifact
Degree of Originality
Intended Use (study, exhibition, etc.)
Curatorial expectations or requests
Provenance/History of Artifact
Environment in which the artifact is to be exhibited or stored

Using these factors, we now will compare the treatment of three seventeenth century leather chairs, all of which were in severely deteriorated condition. They are as follows: a back stool with an American or English attribution; an upholstered armchair (for which the grant was written); and a Spanish colonial armchair.

The first two chairs are located at Pennsbury Manor, William Penn's home on the Delaware River in Morrisville, PA. Both of these chairs are on exhibit in the house, where they aid in the interpretation of the period and the lifestyle of William Penn in 17th century America. The

Spanish colonial chair is owned by the Brooklyn Museum in New York, and is part of an upcoming traveling exhibition.

A discussion of the treatments for the three chairs follows, with treatment option selection based upon the evaluation and relationship to the previously mentioned criteria.

BACK STOOL

The back stool is a simple four legged chair without arms. The stool is constructed from spiral turned front legs and stretchers. The lower half of the rear posts are also turned, and these members are mortise and tenon joined and pinned with wooden dowels. The stool is upholstered with a polyester printed fabric on the seat and back rest.

Condition: The chair is unstable due to an old insect infestation and numerous nail and tack holes; these weaknesses have caused two of the four legs to fracture and has compromised the structural integrity of the proper left seat rail. The piece has also been reupholstered using a modern polyester fabric. The exposed chair frame has been recoated with several applications of varnish and shellac.

Degree of Originality: The original upholstery and support materials had been replaced with modern materials.

Intended Use: The backstool is to be exhibited in a historic house/period room setting, and function as a part of a didactic backdrop.

Curatorial Expectations: The curator requested structural stabilization, and that the chair be reupholstered using materials appropriate to the period. It was also requested that after treatment the chair would appear in a condition that would be indicative of period use.

Provenance: Unknown, purchased from a used furniture shop in New York, NY.

Environment: Pennsbury has extreme humidity fluctuations, and the house is heavily used, in particular by large school groups. Therefore, stability and durability of the materials chosen for conservation becomes extremely important in the overall treatment approach.

Treatment Synopsis: All modern materials were removed to complete needed structural repairs. These materials were retained as part of the permanent file for this object. An additional factor used to determine this treatment was the physical evidence revealed upon removal of the modern upholstery. Original tack holes found on seat rails, posts, and crest rail were discovered which determined a decorative tack pattern which would be incorporated into the final phases of the treatment.

A non-invasive upholstery system was chosen based upon work of Leroy Graves in Colonial Williamsburg. This procedure was taken one step further by development of an upholstery support system which would allow the chair to serve as a functional object. This was achieved using polyester and fiberglass laminate panels for the back and seat foundations upon which an Ethafoam profile and show material were attached. Curatorial research indicated that options for reupholstery would include either turkeywork (a type of tapestry) or leather. Leather was chosen because a suitable textile was not available. The leather was "aged" by coating it with shellac, toning with dry pigments, and distressed before it was glued to the fiberglass panels. Brass tacks were inserted through fiberglass supports and adhered with Acryloid B-72. The undersides of the seat cushion and back were covered with linen and upholstery strap to create a finished appearance. The severely damaged frame was impregnated with 5% polyvinyl butyryl in ethanol. Areas of loss within the frame were reintegrated with a carvable epoxy, and toned to match the finish.

The leather seat and back panels could then be easily removed to reveal the original chair frame, yet present an artifact that was appropriate to the period room settings found at Pennsbury Manor.

LEATHER ARMCHAIR

This high backed armchair is upholstered in Russia leather, stuffed with a base fiber, and backed with linen. The leather has been painted, decorated with silver leaf, and varnished. Currently the edges of the leather are trimmed with an embossed leather strip attached with brass tacks.

Condition: The upholstery on the chair is in unstable condition. On the leather back are two large, complex tears and there are large areas of loss on the bottom, the proper left side, and the upper proper left corner. The leather is desiccated and stiff, and red rot is evident in some areas. The cellulosic fiber stuffing is exposed, and protrudes through the tears in the leather on the chair back.

The powdery linen on the reverse of the chair back is torn and stained, and a complex tear in the rag paper backing is visible through the tears in the linen. The leather used to cover the seat is less damaged. The exposed grain side is cracked and there are losses to the surface of the grain layer. There is a 7" tear on the front edge of the seat, and the interior stuffing is visible. The embossed leather stripping has severely disintegrated and only fragments of the decorative edge stripping remain. The chair frame appears to be in stable condition, with the exception of a break in the proper right stretcher above the intersection of the lower horizontal back support. Glue blocks and braces had been added to the underside of the chair for additional support. The proper right front leg has been broken, and poorly repaired using a putty-like material which has shrunken and cracked over time. The overall condition of the chair is unstable and unfit for exhibition in a historic house or period room setting.

Degree of Originality: While it appears that the original upholstery is intact, complete with the original wrought nails, the embossed leather stripping is a later addition as indicated by the modern wire shanked upholstery tacks used to hold the decorated leather strips to the frame.

Provenance: Virtually unknown - purchased ca. 1983 in Chester Co., PA and used sporadically as an office chair. It was donated to Pennsbury Manor in 1991.

Curatorial Expectations and Intended Use: Pennsbury desired an exhibitable piece of furniture to complete the late 17th-early 18th century furnishings at their historic site. The Director of Pennsbury applied for a grant for treatment, and the initial treatment proposal included partial removal of leather upholstery, stabilization of underupholstery, lining and reapplication of the upholstery.

The granting institution felt that the integrity of the chair, unusual because so few seventeenth century pieces of furniture retain original leather upholstery, would be compromised by the proposed treatment. It was recommended that chair be placed in storage, on its back, for study and research.

This was unacceptable to Pennsbury for several reasons: a study collection did not exist; there was very limited storage space; and the gift was conditional upon its display or exhibition. The grant application for the chair was resubmitted using the same treatment proposal; however, statements were added explaining the treatment rationale and notification that if the treatment was again deemed unacceptable, the chair would be returned to the donor. The proposal, as originally written, was accepted.

Environment: Pennsbury has extreme humidity fluctuations, and the house is heavily used, particularly by large school groups. Therefore, the stability of the materials and the resilience of the treatment weighed heavily in the choices made prior to conservation.

Treatment Synopsis: The leather upholstery was removed from the chair back to allow for tear realignment, lining, and to add supplemental support needed to transfer the weight of original stuffing away from the leather upholstery itself.

The reverse of the leather was powdery, flaking, and required consolidation in order to stabilize it for a backing procedure. Pliantex, a 5% solution of ethyl acrylate in ethyl acetate, was applied by brush to the flesh side of the chair back. The consolidant was chosen for its flexibility and non-staining properties. The tears were repositioned with sutures made of Reemay coated with Beva. It was critical to maintain the convex contours in the leather panel or it would become impossible for it to be reattached in its original position on the chair frame.

The cellulosic fiber stuffing was slightly reshaped by hand, and encased in a contoured bag of spun bonded polyester. This was further reinforced using a sling or cradle of the same polyester.

The top of the sling was attached at the top rail of the chair back to support the weight of the flax stuffing.

Areas of loss in the leather panel were compensated with new pieces of skived mineral tanned leather. These leather inserts were attached with Beva 371. The leather inserts were colored using a mixture of microcrystalline wax/rosin toned with dry pigments.

The leather back was completely lined with two layers of Reemay that had been flock-sprayed with Beva 371. This backing was attached to the consolidated flesh side of the chair back using heated tacking irons; the newly lined leather upholstery was then repositioned over the stuffing. Beva was then applied to the edges of the chair frame, and the edges of the upholstery were heat-set to the chair frame.

The seat upholstery was not removed. Tears in the leather were repaired with new skived leather inserts, and filled with microcrystalline wax/rosin toned with dry pigments.

The torn linen on the reverse of the chair back was covered with a new piece of linen that was pressure-fit by inserting the edges of the new textile between the original fabric and the chair frame.

When the embossed leather tape trim was removed, evidence of an original trim was found in localized areas. The modern replacement trim was so deteriorated that upon consultation with the curator a decision was made not to reattach these remnants on the seat back. With curatorial assistance, a more appropriate gimp was attached to the chair back using Acryloid B-72. A matching gimp and fringe was also applied to the lower edges of the chair seat, over the older leather tape, attaching it to the tack heads with 50% Acryloid B-72 in acetone.

The unstable front leg was reinforced using a carvable epoxy putty, and toned to match the surrounding finish. The break in the horizontal back support was repaired using hot hide glue. Note: The embossed leather trim and decorative brass upholstery tacks were not removed from the seat rails in order to maintain a physical historic record of previous alterations.

SPANISH COLONIAL CHAIR

The armchair is constructed from turned front posts, stretchers, and sawn rear posts. These members are mortise and tenon joined and in some instances pinned using wooden dowels. The tooled leather seat and back are stretched across the frame and tacked into position using wrought nails and decorative tacks.

Condition: The chair is in unstable condition. The frame is cracked and split, and all glue joins are loose. The leather is severely deformed, torn and brittle. Oozing oils are evident overall.

The flesh sides of the seat back and chair back are extremely friable.

Degree of Originality: Two-thirds of the mahogany frame has been replaced. Based upon tool and saw marks, these replacements appear to have been executed in the 20th century. Seat support straps are made from pieces of rawhide and embossed leather which had been cut from some other decorated leather panel. The leather upholstery appears to be consistent with the period of manufacture; however, it is impossible to say with any certainty that this leather is original to the chair frame.

Intended Use: This chair was conserved for exhibition in a gallery setting. Given its fragility and degree of damage, it was considered unexhibitable in its current condition. Therefore, treatment for stabilization and aesthetic purposes was required.

Curatorial Expectations: The chair was required to be in stable condition for travel and exhibition purposes and the appearance needed significant improvement.

Provenance/History of the Artifact: The chair was collected during the 1940s for The Brooklyn Museum.

Environment: The chair, part of a traveling exhibition, is expected to be subjected to at least moderate climatic changes during transportation from venue to venue.

Treatment Synopsis: Due to the extreme and severe deterioration of all elements, it was necessary to completely disassemble the chair. All splits and fractures were repaired using hot hide glue, and where necessary, inserts made from mahogany were added.

The leather was first cleaned using swabs dampened with saliva to reduce accumulated grime, and some oozing oils.

The leather chair back was removed, and humidified using slightly dampened blotters applied to the reverse or flesh side of the panel. The leather was then allowed to dry slowly under weights, while maintaining a shape consistent with a pattern of use. After consolidation using a 5% solution of Pliantex, the flesh side of the leather chair back was lined with Reemay which had been flock-sprayed with Beva 371. Using a heated tacking iron, the Reemay lining was attached to the chair back. Thin chrome tanned leather was then attached to the reverse of lining. The leather was adhered, flesh side out, to create an appearance similar to the original panel, prior to treatment. All old repairs and inserts were left intact.

The seat required a less invasive treatment. Beva coated Reemay sutures were applied to the reverse in order to mend tears. The exposed, or top side, was filled using microcrystalline wax toned with dry pigments. The leather was reattached to the frame with the original tacks.

CONCLUSION

The purpose of this paper is to illustrate, review, and consider the necessary factors required to evaluate an appropriate course of treatment for objects which are to complement historic settings; many of these factors, which in part dictated treatment, are interrelated and interdependent. Having been through this process, and having had a treatment proposal rejected for being too radical, we have found that the context and rationale for treatment need to be as fully understood and explained as the specifics of the treatment itself. We, as conservators, bear this responsibility and also that of extending to our colleagues the professional courtesy of withholding criticism until full consideration is given to the factors determining treatment choice, or the parameters within which they work.

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HOW WOULD YOU MOUNT A RAMBARAMP?

Christine Del Re and Paul Countryman

Introduction

In 1986, the Field Museum of Natural History in Chicago embarked on a major renovation program of its permanent exhibition galleries, in preparation for its Centennial in 1994. Part of this exhibition renovation program included the reinstallation of its world famous Pacific ethnographic collections. The first section of the exhibit, entitled "Traveling the Pacific", opened to the public in November 1989. The second phase, called "Pacific Spirits", was completed a year later.

The Figure

One of the objects chosen for installation in "Pacific Spirits" was an ancestor figure from Vanuatu called a Rambaramp (Figs. 1-3). Vanuatu, a group of islands in southeast Melanesia, was known prior to 1980 as the New Hebrides. It lies to the northeast of Australia and is located between the Solomon Islands in the north, and New Caledonia in the south. This figure presented both the Conservation Division and the Design and Production Department with unusual mounting and display challenges, which will be the focus of this paper.

Purpose, Cultural Significance and Technology

A Rambaramp figure was a commemorative statue, or rather a memorial figure, that was made of a man who had died; when it was produced, the skull of the deceased was incorporated into the figure. The actual size of the figure, its decoration, and the care with which it was executed depended on the rank that the deceased had achieved in one of Vanuatu's male-only secret societies. In fact, all of the designs painted on the figure, and all of the decorative elements on it, reflect the rank and status that the man had attained while living. The Rambaramp figure traditionally resided in the men's ceremonial house of the village and was brought out to participate in important ceremonies that took place in the village.

Materials and Technology

The Rambaramp figure is made with a human skull; a human hair wig; two necklaces, one of fiber and one of oliva shells; a spider conch shell for its proper right hand; and the jaw of a young pig for its proper left hand. Its torso, arms and legs have an interior structure of bamboo poles wrapped with multiple layers of pandanus leaves. The layers of pandanus leaves appear to alternate in direction -- one horizontal and one vertical -- with the topmost visible layer of pandanus leaves on the torso and legs oriented vertically. This final layer was then bound horizontally with thin bands of another plant fiber.

Covering the pandanus leaves is a layer of what is referred to in the literature as a vegetable paste, made of coconut milk, breadfruit juice, and ground creeper root. The paste was then painted with black, white and two different shades of red. The pattern, as already mentioned, depended on the rank achieved by the dead man during his lifetime.

The head is made from a human skull which contains both human and pig's teeth. The skull, like the body and torso, was also covered with vegetable paste. The paste was modeled to resemble as closely as possible the deceased person it is representing, and then painted. Atop the skull sits a human hair wig made on a cane framework.

A palm leaf sheath is wrapped around the ankles of the figure, which has no feet. When used outside of a men's house in Vanuatu, the figure would have been displayed by sticking the bottom of the legs directly into the ground.

Condition

The overall condition of the figure was fair to poor. There were a number of structurally weak areas: both "hands" were only loosely connected to the arms, the head/neck attachment was insecure and unstable, and both of the arm/shoulder joints appeared to be unstable. These four unstable areas were, not surprisingly, those areas that were secured with vegetable fiber lashings. The vegetable paste layer in these areas was broken, damaged and coming apart. There was considerable movement in all of these areas, but nothing actually appeared to be in immediate danger of falling off. In fact, the movement of the arms had caused considerable damage to the pandanus leaves and vegetable paste on the proper right hip

It seemed safe to assume that the weaknesses seen in these areas were caused by obvious inherent vice in the manufacture of the piece, aggravated by 100 years of improper mounting conditions. The Rambaramp figure had been displayed vertically with no secondary support systems from 1892 until the recent past. We assume that the figure was mounted simply by placing pipes up the bamboo in the legs.

The leg/torso connection was solid, as was the torso proper. However, multiple layers of pandanus leaves were broken in the upper chest area underneath the fiber necklace. The vegetable paste layer had been lost from this area. The structure of the upper chest in general was weakened, but it was not falling apart.

Conservation and Exhibition Criteria for the Mount

1. Conservation Criteria

Before we began to evaluate the artifact, the Conservation Department felt that, given the ephemeral nature of the artifact, the only way to guarantee the long-term preservation of the object would be to display it in a horizontal position.

The evaluation, which included both examination and handling of the artifact itself, and a thorough examination of two full sets of X-rays, was done in collaboration with the mount makers who would be responsible for mounting the object. This assessment showed that the head was not laterally stable on the figure and was quite heavy, thus making the object itself top-heavy; and we were uncertain about the amount and strength of the internal bindings. Furthermore, we were concerned that the constituent materials, which were almost entirely dried plant materials, had become desiccated and brittle over the years, and as a result could not be expected to maintain their support and structure indefinitely. In addition, the object had been displayed inappropriately for a very long time. An unknown degree of stress had been placed on the materials and the object itself as a result of these old mounting methods.

Having assessed the results of our examination, we decided that the figure required a well-designed mount that would fully support it, and that specific parts of the object needed support with separate brackets. Each hand required a bracket that would support it, along with the weight of the entire arm, so that the vegetable paste would not continue to fracture in those areas. The head and neck needed their own support, as did both legs. We also wanted to make a body cast for the object to support it in its entirety, since we felt that no matter how stable the artifact appeared at present, the materials that the figure was made from would not be able to support their own weight indefinitely.

2. Cultural and Curatorial Display Criteria

After consultation with the Director of the Vanuatu Cultural Centre, our exhibit developer stipulated that the eyes of the rambaramp figure be located so they would be above the eye level of any female visitor to the exhibit. No woman may look down upon a Rambaramp! We therefore needed to determine the average height of our typical female visitors, in order to meet these cultural height and eye-level criteria.

Our exhibit developer also felt very strongly that the figure be displayed in an upright, vertical position; as it had been for some sixty years previously. She emphasized the important fact that a Rambaramp was not considered "dead" in its cultural context; she felt that displaying the figure in an upright posture would make it look alive. This posture would help convey that message to the public. (We must confess we had considerable difficulty believing that any visitor would think this figure was anything but dead, even if it was in a vertical position!)

These were the conflicting criteria that we had before us when mount development began. As is often the case in conservation, balancing the long-term preservation needs of the artifact against its educational function in a public exhibition was going to be a challenge.

At this point, taking into account requests from the Developer, in a spirit of compromise, we recommended that the figure be displayed at a 45-degree angle to ensure the long-term preservation of the piece.

Mount Materials

1. Conservation Criteria

The conservation criteria that the mount material had to meet were ones familiar to all of us. The material should be inert and stable, and not generate any degradation products that might be harmful to the artifact over time; however, it also needed to be strong.

Given the delicate and fragile nature of this particular artifact, we felt that it could not tolerate very much handling while its mount was being made. We wanted a material that could easily be manipulated, would readily conform to the curves of the figure, and that would cradle the artifact as completely as possible to support its dry and brittle fabric well into the future.

We also left open the option of raising the angle of the object slightly, if the mounting system that was developed could support the piece sufficiently to allow for the weight transfer.

2. Mount Shop Criteria

The mount shop had to meet its own criteria in making the mount for this object. The usual round and flat metal stock that was often used for mounts would not be wide enough to provide adequate support for the entire piece. The use of Plexiglas was ruled out for a number of reasons, largely because it would not be possible to fit the Plexiglas adequately around the piece due to its fragile nature, i.e., the object could not be handled the way a piece of wood or bone could be to fit the Plexiglas around it. It also seemed that the Plexiglas would have to worked in rather small pieces to get it to fit adequately, and then these smaller pieces would need to be joined together.
Initially it seemed that making a polyester resin and fiberglass cast would be the ideal solution, but the potential safety hazards of using such large quantities of polyester resin in our mount shop facilities could not be adequately addressed with the resources available at that time.

It was at this point that we decided to investigate the materials used in the medical field to make body casts, since that was essentially what we wanted to do: to create a body cast to give adequate support to the object.

Orthoplast

The material researched and tested as a mount material for this object is called Orthoplast[1]. It is commonly used as a splint material for fracture and body braces. Orthoplast is made from trans-polyisoprene, a rubber product, and is a thermoplastic material softening at 150-170^{0}F. It has excellent strength and moldability properties, and can be formed at moderately low temperatures by warming it with water or dry heat. At this temperature (150-170^{0}F), the crystals melt and slowly reform. Recrystalization takes about 20 minutes.

Orthoplast is an unusual thermoplastic material, combining excellent formability, strength and cohesion in a way that simplifies the fabrication of even the most intricate mount designs. It is a durable yet versatile material that can be cut or molded to any shape when heated, and it will adhere to itself, or "self-bond," when hot. This bond is very strong and can withstand a 100 lbs per inch pull test.

The material can be riveted, strapped, bonded, hinged or butt-bonded to meet any mount-making needs; and it can easily be cut and molded to curved contours without wrinkling. Edges can be easily trimmed and finished. Setting time, from heating to complete cooling, is three to five minutes.

The use of Orthoplast for this particular application greatly appealed to us because it was so easy to deform at moderate temperatures, and it would conform so well to the object with little manipulation.

Technical Data [2]

The technical data available about Orthoplast states that it is made from *trans-polyisoprene.* Gutta percha and balata are natural products predominantly made of trans-polyisoprene. *Cis-poly-isoprene,* the isomer of *trans-polyisoprene,* is the composition of rubber directly taken from the tree. Isoprenes have a naturally occurring double bond and consist of pure hydrocarbons. No sulfur-bearing materials, mercaptans, or chlorine compounds are used in the manufacture of Orthoplast; only antioxidants are added during manufacture. Orthoplast will probably embrittle over time due to oxidation, but it seems that the process of embrittlement can strengthen the material, which we see as an advantage in our application.

In its most common application in the medical field, as a body brace, Orthoplast will develop stress cracks after 6-8 months of constant daily use. However, our application would be to keep the material under a constant static load, and not expose it to continual stress. Richard Green, a research scientist at Johnson & Johnson (the manufacturers of Orthoplast) felt that it would last as long as any other currently used rubber or plastic material. He also stated that if the material was worked and left for 2-3 years, it would embrittle through oxidation, and could not be re-worked and probably would not adhere to itself if reheated after oxidation, but he did not believe that it would otherwise lose its shape or deform (creep) over time.

Orthoplast comes in 18" x 24" plain sheets, and 24" x 36" perforated sheets. We used the larger perforated sheets for this project.

Testing

Orthoplast was subjected to three-months of (contact) Oddy testing, using the prescribed silver, lead and copper alloy blanks, and yielded good results.

Scott Williams of the Canadian Conservation Institute analyzed Orthoplast and found it to be composed of the hydrocarbon polymer trans-polyisoprene with amorphous silica inorganic filler. Hydrocarbon plastics generally do not produce harmful degradation products as they age. No extractable components or any other materials detrimental to its use in conservation were detected in the product. Based on his chemical analysis, he considers Orthoplast to be chemically suitable for use in conservation.

Mount Fabrication

Before work with the Orthoplast began, construction-paper patterns were made to define the outline and basic shape of the figure. Four patterns were needed for the full mount; these were then cut out of the Orthoplast with regular surgical scissors.

Before the Orthoplast can be worked, it needs to be heated with a heat gun; it can also then be solvent bonded with trichloroethylene. We used the solvent as a precautionary measure; it is not necessary to get the material to bond. The areas to be joined must be heated thoroughly. The working temperature is about 160°F, but the easiest procedure is just to heat the material until it responds. Curing time after application of the heat gun and solvent is five minutes. We used Tyvek or Mylar as a separating layer at all times between the object and the Orthoplast [3].

Because we were concerned about possible failure of the polymer over time, despite the fact that it would be used in a static load situation indefinitely, the mount makers decided to reinforce the Orthoplast body cast with a flat stock and half round steel support[4]. The steel support that holds the body cast and legs was welded together; the separate attachments for the hands and head were soldered. The support was bonded to the main Orthoplast support with small strips of Orthoplast that were securely solvent-welded to the back of the body cast (Figs. 2-3).

The supports for the legs were difficult to make. Previous mounting systems had damaged the ends of the original bamboo legs, and one leg was shorter than the other. Using a combination of a flashlight and the X-rays, we located the nodes in the bamboo legs, and found that both legs had previously had something pushed up into them which perforated the first node in each bamboo pole. Having discovered these existing holes in the nodes, we felt comfortable putting something else in as a support, provided it did not fit too tightly.

The materials chosen were 1/2" steel rod and a steel pipe into which the rod would fit. These were padded with ethafoam at the top. The pipe was inserted up to the first node; the rod passed through the hole in the node and stopped at the second node, which was unperforated. This arrangement allowed the figure to be supported in two places. An extension was added to the shorter leg so that the figure could stand on two legs of equal length.

The head was supported with flat brass stock; steel could not be used because it was too thick and the wig would not fit over it. The support was made in a cross pattern. A hollow half-sphere of Orthoplast was placed on the support to cradle the occipital bone at the back of the skull. The mount provides excellent bracing for the skull in that area. The wig then fits over the brass support.

The interior contour of the conch shell was duplicated using an annealed piece of 1/16" brass stock. The other mount for the jaw bone was made using the same brass stock. It has four little clips on which the jawbone rests; the mount does not actually grip the jawbone, but simply supports it from underneath while gravity holds it in place.

The two hand brackets are held in position with half-rounds of steel and tubular slip rings. The mount that comes down from the arm is made of half-round steel and has a set pin soldered into place. The hand mount, which is also made of half round steel, is held in place by a tubular slip ring that slides down into a set position. This in effect holds the two half-rounds together, and keeps the mount from pivoting. The two hand mounts are simply held in position by the slip ring; they can then be de-installed by sliding up the slip ring and removing the mount.

Mount Finishing

Because we were extremely concerned that the surface of the body cast might become tacky over time, and in response to aesthetic requests by the Design Department, the Orthoplast body cast was finished as follows. A layer of CODA, an acrylic film adhesive[5], was applied directly to the inside of the Orthoplast. To that we applied a layer of Testfabrics cotton velveteen, which had been dyed a light beige, in the hope that the mount would "disappear." The artifact was then separated from these layers by a sheet of Mylar that was cut in the shape of the figure. This ensured that the object would not be resting directly on the rubber-based material, should it became tacky, and it also served as a barrier between the Orthoplast and the object should it start to off-gas in the future.

Final Exhibition Appearance

Our final compromise in conservation was to allow the figure to be displayed on a 55 degree angle, since it seemed that the mount more than adequately supported all of the delicate and fragile areas. Raising the artifact to that angle did not seem to cause any perceptible gravitational shift of the materials in the object.

In conclusion I would like to say that we were very pleased with the results that we obtained working with this material on this particular artifact and under these conditions. We feel that the working properties of Orthoplast were ideal in these circumstances.

I would like to recommend that this material be considered for wider use in similar applications, especially where the object can be protected from its potential drawbacks -- with barrier layers, or a secondary support system. It also can be potentially very useful for temporary mounts, or other similar short term uses [6].

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(At the time this work was done both authors were employed at the Field Museum of Natural History)

Endnotes

1. Orthoplast, which is identified as a low temperature splinting material, is available from one of the large national orthopedic and medical supply houses such as Alimed (1-800-225-2610) or Sammons Preston (1-800-323-5547).

2. Technical information on Orthoplast was provided verbally by Richard Green, presently a consulting engineer with Johnson & Johnson. He was previously in the Research Department at Johnson & Johnson for 25 years. Address: Richard Green, Operations Department, Johnson & Johnson Professional, Inc., 501 George St./ED 206, New Brunswick, NJ 08901.

3. Madeleine Fang of the Phoebe Hearst Museum of Anthropology has had success using a plastics welding heat gun to join Orthoplast. She used a Leister-Gibly model that heats to 100-600°C. One could also use a Makita Wall Stripping heat gun that heats to 1200°F.

4. Orthoplast has been found to become brittle with oxidation and through use. Previously heated and worked samples recently (January 1996) found in the mount shop of the Field Museum did crack when put under load. Therefore the original use and application of this material is still as recommended in this case study: under constant static load, and with a support system. However, I feel that its low working temperature and its ability to form easily over fragile and sensitive materials still offers considerable advantages.

5. CODA acrylic sheet adhesive is available from 194 Greenwood Ave., Midland, NJ 07432 (201-444-7755).

6. During the course of my follow-up research for the publication of the article a number of other similar materials have come to my attention. One is Orthoplast II (a polycaprolactone, R. Green, 1/96) which is less strong than Orthoplast but less expensive, and without the double bond (therefore with better aging properties). Another material is Aqua-Plast, a polyester material sold to the theater and crafts industry 1-800-526-5247 for information). A third possibility is a house brand of Aqua-Plast made by Alimed (see note 1. above) called Multi-form Clear Elastic (this is under development and may not be available yet). I think that all three merit testing and research by the conservation profession. It would also be useful to talk to doctors, physical therapists, etc., to find out what they are using for low temperature splinting materials, and investigate all of those for use in conservation and mount-making applications.

Figure 1. Rambaramp figure before treatment.

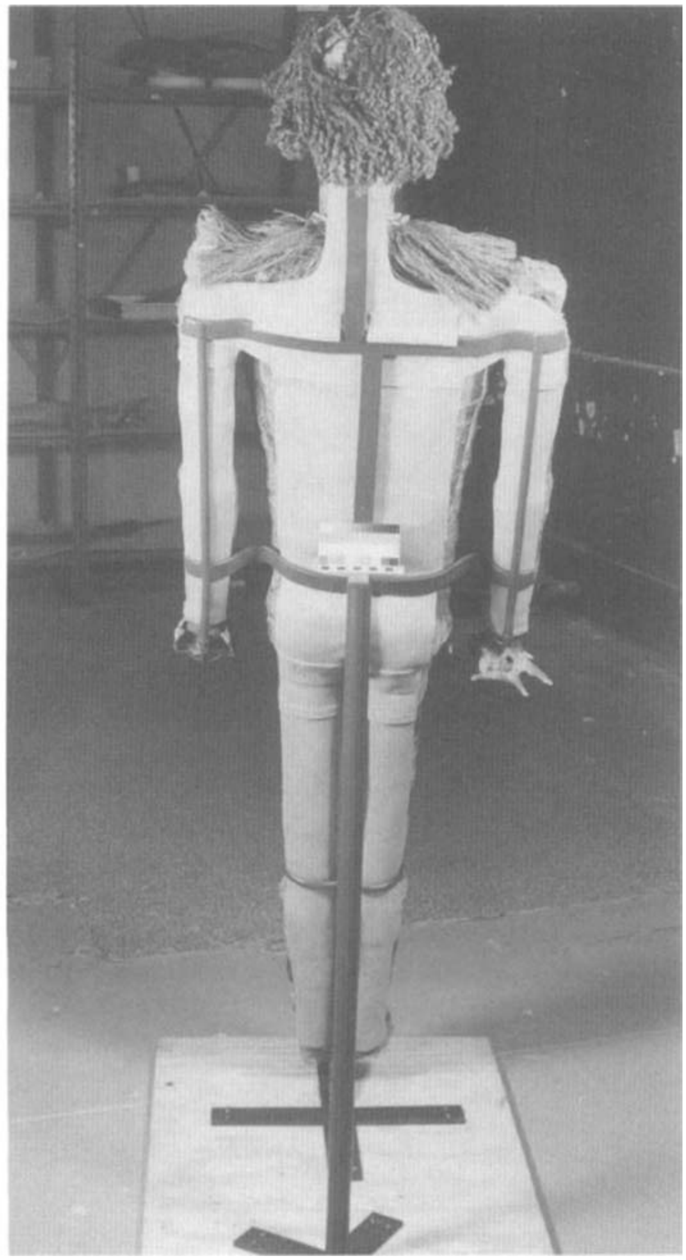

Figure 2. Rambaramp after treatment, back view.

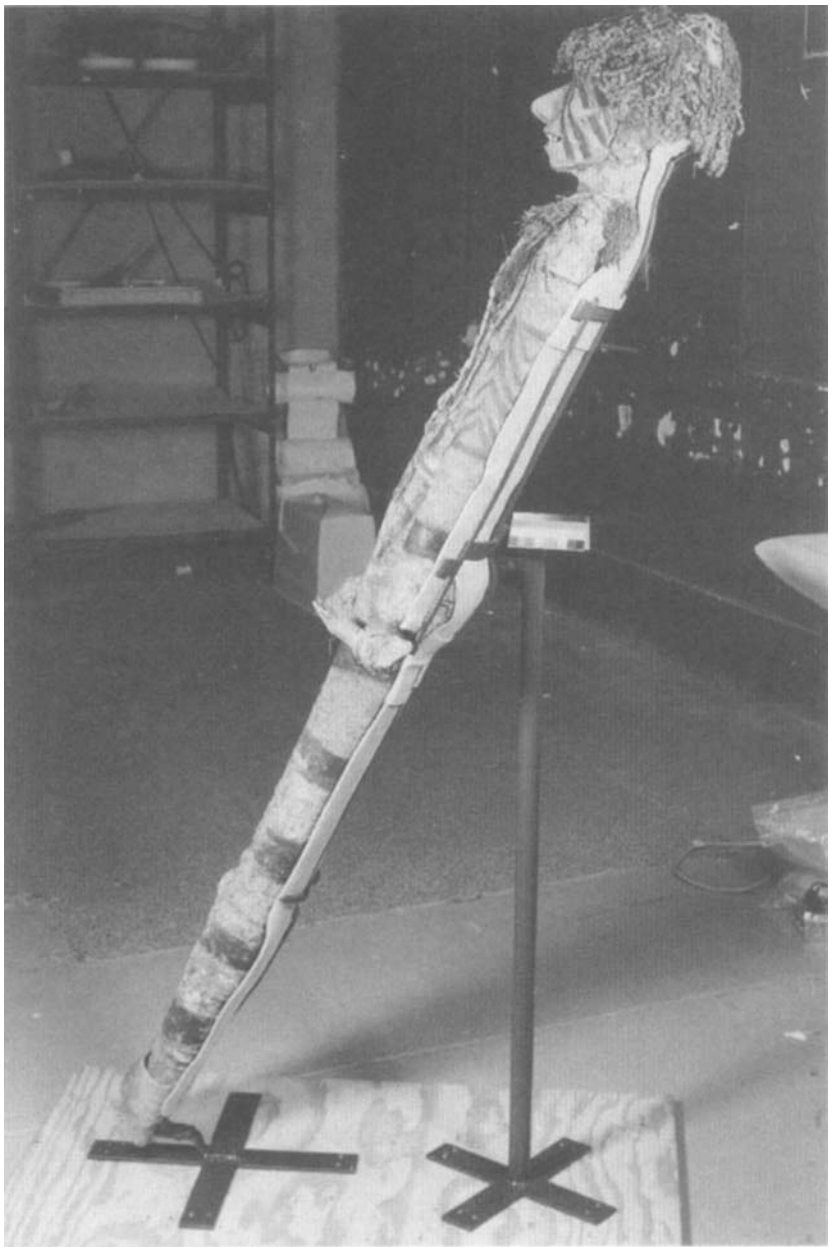

Figure 3. Rambaramp after treatment, side view.

WHAT A RELIEF! A PRACTICAL, INEXPENSIVE APPROACH TO THE CONSERVATION OF A LARGE XIX DYNASTY SANDSTONE STELA

Christina Krumrine and Lisa Kronthal

1. Introduction

In October of 1993 the Brooklyn Museum reopened its West Wing Egyptian Galleries. Approximately 600 objects that had been in storage during the three year renovation were reinstalled into newly designed cases in state-of-the-art, climate controlled galleries. The enormous job of preparing these objects for reinstallation fell upon the Museum's conservation staff during a time of severe financial crisis for the Museum and its primary benefactor, the City of New York.

The Museum's economic woes resulted in staff shortages and in stringent budgets for the conservation department. These strictures were felt most severely during the treatment of several large stone objects in the collection. Faced with the task of reassembling these massive objects, the conservators needed to develop techniques that utilized basic materials readily available in the conservation lab and which required only minimal assistance from the Museum's already overburdened art handlers.

The authors pioneered such techniques during the treatment of a large Ptolemaic limestone sarcophagus lid that had broken into two heavy pieces. The technique was further refined during the treatment of a sandstone stela broken into five large fragments (fig. 1). Both objects were previously repaired using difficult to reverse materials and techniques. This paper will discuss the conservation treatment of the relief in detail and introduce new techniques for structural repair that are simple to carry out and easy to reverse.

2. Dowel and Sleeve Joins: A New Approach

Having carried out many structural repairs on large, heavy stone objects, the authors were familiar with commonly used doweling techniques, most of which employ stainless steel dowels in conjunction with structural adhesives such as polyesters or epoxies. They also knew how difficult and time consuming it can be to reverse this type of structural join.

Could one refine these commonly used techniques to develop a system that eliminated the need for difficult-to-reverse adhesives? Such a system was developed. Instead of adhesives, the system relies on gravity, absolutely parallel drill holes and extremely tight fitting sleeves for the stainless steel dowels.

3. Description

The stela (Fig. 1), which depicts Ramses II, measures approximately 1.7 m in height and 87.2 cm wide. Its depth ranges from 13 - 18.5 cm. and it weighs approximately 275 kilograms . The large monument comes from the Egyptian temple of Amarah West in Nubia and was acquired by The Brooklyn Museum in 1939 (The Brooklyn Museum Archives:1939).

3.1. Previous Restoration

The relief was found in five fragments which were re-attached with plaster and cement soon after excavation. All the previous joins were slightly out of alignment. Figure 2 illustrates the location of the copper and brass dowels and staples used in the previous restoration.

Upon removal of excessive plaster fill on the back and sides of the relief, several of the notched copper and bronze dowels used in the previous restoration became visible. On the sides of the relief there were numerous copper and brass staples which were set into carved recesses with plaster and cement. The exposed dowels and staples were corroded, and the plaster and sandstone surrounding the dowel and staple sites exhibited hairline cracking and spalling.

Inpainting from previous repairs was unsightly and extended onto the original stone surfaces. For all of these reasons, it was decided that all structural and cosmetic repairs should be reversed and the fragments reattached using inert, structurally sound materials.

4. Reversing Previous Restoration

Previous plaster and cement fills on the face of the relief were mechanically removed with scalpels (Fig. 3). Overpaint on either side of the old fills was removed with acetone and cotton swabs without damaging any ancient pigmentation. All of this was done while the relief was vertical.

To address the old internal structural repairs, the stela had to be dismantled from its old wooden backboard and placed horizontally, face down, on a wooden work table. The table top was first prepared with several layers of Volara polyethylene padding followed by two layers of silicone Mylar. The silicone Mylar provided a slick surface on which the fragments could be maneuvered during dowel removal.

Using chisels, the plaster and cement were removed from the breaks on the back and the sides of the relief. The internal brass and copper pins at the horizontal breaks were easy to locate after all the plaster and cement "adhesive" had been removed from between the break edges. These notched dowels, still firmly held by the plaster in their holes, were removed by drilling through the metal with long drill bits. Eventually the metal split and the fragments could be separated (Fig. 4). Separation was easily accomplished by sliding the fragments on the layers of silicone Mylar previously placed on the table.

Once the dowels had been taken out, cement and plaster were removed from within the existing drill holes with chisels. All of the existing holes were approximately 8 - 10 centimeters in length and 4 centimeters in diameter with the exception of the three holes in the curved top fragment. These holes were extremely large and irregular and the brass dowels found in them were bent. This seemed to indicate that the previous restorers had tremendous difficulty aligning the dowel holes along this sharply angled, diagonal break.

5. Leveling and Aligning Individual Fragments

5.1. No-Muscle Method for Moving Large Stone Fragments

In order to move the heavy fragments of the stela, the conservators developed a new "pallet" system which eliminated the need for brute strength to move the five fragments ranging in weight from 15 to 100 kilograms.

Figures 5 and 6 illustrate the new pallet system used to maneuver the relief. First, the table was covered with a single sheet of silicone Mylar which was attached to the table by applying double sided tape to the uncoated side of the Mylar film. A template of each fragment was cut out of paper, trimming approximately 2 to 4 centimeters from the perimeter of each shape.

The slightly reduced template of each fragment was then traced onto a thin, rigid board of Masonite. The Masonite was cut to shape with a jigsaw. Each pallet was then covered with silicone Mylar on one side, and a thin sheet of Volara polyethylene padding on the other side. Both of these materials were attached to the Masonite with double-sided tape. The bottom, silicone Mylar-side of each pallet was placed on the prepared table. Each fragment was then lifted onto the padded side of its corresponding pallet, face up. The interface of the two silicone Mylar surfaces enables the conservators to glide each fragment across the table with minimal effort.

The back surface of the relief was very irregular and varied dramatically in thickness across its length. This meant that each fragment had to be leveled in relationship to the others, something that was not accomplished during the previous restorations. The pallets made proper alignment a simple task. Each palletized fragment was presented to its mate by sliding it on the table, then both fragments were leveled using pre-cut wooden shims. After all five fragments were leveled in relationship to each other, the shims were permanently adhered to the individual Masonite palettes with hot-glue. By adhering the shims to the palettes, there was never a need to re-level the fragments during the course of treatment.

6. Assembling the Fragments

6.1. Dowels

As described earlier, the relief fragments were not properly aligned during previous repairs. The pre-existing dowel holes were not parallel and they were generally too narrow and/or too short to accommodate dowels and sleeves of adequate length and diameter. The configuration of the breaks and the weight of the fragments called for a total of seven 3.5 cm diameter stainless steel dowels: three along the top diagonal break, two along the middle, horizontal break, and two at the bottom vertical break (Fig. 7).

All dowels were 25.5 centimeters in length except for those used at the bottom vertical break. Since all the weight of the upper fragments would rest on the bottom two fragments, longer 31.5 centimeter dowels were used at the vertical break for added strength.

6.2. Creating Absolutely Parallel Dowel Holes

Figures 8 and 9 illustrate a simple rig that was developed for obtaining absolutely parallel dowel alignment along break edges. The rig was constructed from a single, squared length of wood screwed to a wooden "L" shaped stand. The wood strip had to be long enough to accommodate two corner clamps which would hold the dowels in their parallel position and would span the distance between the dowel holes. One arm of each metal corner clamp was secured to each end of the wood strip so that the second, extended arm of each clamp was positioned perpendicular to the break edge. A stainless steel rod was then placed in the extended arm of each clamp. This system maintained a constant distance between the two parallel dowels.

As the rig was presented to the break edge, the two parallel dowels in the rig were simultaneously inserted into the pre-existing holes. Since the pre-existing holes were out of alignment - that is, not parallel - the rigged, parallel dowels would scrape against the interior surfaces of the holes. The holes therefore needed to be widened at the points where the dowels scraped. The hole interiors were drilled with a metal bur until they accepted the parallel, rigged dowels. The size of the existing dowel holes had to be lengthened to accommodate the new stainless steel dowels, and slightly widened to accept both the dowels and new internal sleeves. Since the new joining method was going to rely on the mechanics and rigidity of internal dowels and sleeves - and NOT on adhesive - these longer dowels were needed to ensure adequate strength at the joins.

Once one set of holes was aligned and lengthened along a break edge, the rigged dowels were re-introduced into the drilled holes and held in position temporarily with dental wax. The rig was then removed, leaving the dowels extending outward from the holes. The corresponding fragment was brought to meet the extended dowels and the break was slowly closed. Again, wherever the dowels scraped, the holes needed to be widened. The two holes along the second break edge were widened and lengthened until all the holes were perfectly parallel and the fragments closed tightly with the two dowels in place.

6.3. Creating Tight-Fitting Epoxy Putty Sleeves

It is extremely difficult and expensive to buy stainless steel rods and matching sleeves that have little "play" between the two. Rods can be precision milled to fit snugly into stainless steel sleeves, but this can be very costly. Since the goal of the treatment was to eliminate structural adhesives and rely instead on gravity and the mechanical rigidity of a dowel and sleeve join, only minimal movement of the rod within the sleeve could be accepted. Customized, form-fitting epoxy putty sleeves proved to be an economical answer to these problems.

All holes were first lined with a 1/8" thick isolating layer made from a paste comprised of Acryloid B-72 bulked with fumed silica and cellulose powder. After drying, this lining was sanded until it had a very smooth, regular surface. This thick, smooth isolating layer was applied to ensure the reversibility of the epoxy putty sleeves. Saturating the isolating layer with acetone or ethanol will soften the lining material and allow an epoxy sleeve to be pulled out of the drill hole.

With the rigged dowels sitting in their corresponding holes along one of the break edges, Pliacre epoxy putty was carefully packed around the dowels in the hole. Before doing this, however, the surfaces of the dowels were coated with petroleum jelly and covered with a single layer of plastic wrap to prevent the epoxy putty from sticking to the dowels. This procedure can be seen in the foreground of Figure 9. When the epoxy set, two rigid, absolutely parallel, tight fitting epoxy sleeves had been created around each dowel. Figure 10 shows the stratigraphy of the dowel hole interiors.

To create matching sleeves on the corresponding break edge, the dowels were inserted into their new, hardened epoxy sleeves and their protruding ends were again isolated with petroleum jelly and a layer of plastic wrap. These extended dowels then served as a rig for the second set of sleeves. Soft epoxy putty was inserted into the holes along the opposite break edge, and, as the two fragments were closed together, the dowels pressed into the soft epoxy (Fig. 11). Once the epoxy hardened and the fragments were pulled apart, the plastic wrap and petroleum jelly were removed. The dowels were then reinserted into the sleeves on one break edge and the matching fragment was joined by sliding it onto the extending dowels.

The result is a purely mechanical joining system which eliminates the need for structural adhesives.

6.4. Complex Dowel Alignment on Sharply Angled Breaks

The simple rig in Fig. 8 had to be refined to accommodate three dowels along the top of the stela, which had a sharply angled diagonal break. This break edge was too long and angled to use a simple rig with one horizontal strip of wood. Instead, two individual rigs had to be "stepped", one behind the other (Fig. 12). A simple corner clamp was secured to the outside edge of each rig's horizontal wooden element, then the rigs were glued down to a Masonite pallet. The rigs were kept parallel to one another by placing a squared length of wood between the two and gluing it to the Masonite pallet as well.

Whenever more than one rig is used to align dowel holes, each rig MUST be glued to the same board. If not, when the rigs are moved during the processes of aligning the holes and making sleeves they will not remain parallel. If the dowel holes and their corresponding sleeves are not parallel, the joined fragments will not be properly aligned. The dowel holes along the sharply angled break were prepared the same way as the other holes, with an isolation layer and epoxy sleeve (Fig. 13)

6.5. Joining the Fragments

Before the relief was assembled, all its break edges were consolidated with a 30% solution of Acryloid B-72 in ethanol. During the transport of the relief into the gallery, we wanted to be certain that there would be no movement along the length of any of the dowels. For this reason, Acryloid B-72 bulked with fumed silica was used in some of the sleeves as a precautionary measure (Fig. 7). At the diagonal and horizontal breaks, the dowels were adhered in their sleeves along the lower break edges only. At the vertical break, both ends of the dowels were notched and adhered in their sleeves. This was done because any movement of the two fragments at the vertical break could potentially exert pressure on the dowels in the upper breaks.

Once again, it is gravity, the tight fitting sleeves and parallel dowels which enables the piece to stand without <u>any</u> structural adhesive. To reverse the joins, one need only lay the relief horizontally and pull the fragments apart. The Acryloid B-72 along the vertical break need only be softened with solvents.

7. Transporting and Mounting the Relief

Belt clamps were wrapped around the entire stela to secure it to its wooden platform. A second platform, constructed from wood and padded with thick polyethylene foam, was placed on top of the object. The two platforms, with the stela in between, were then strapped tightly together with the belt clamps and lowered with a forklift onto dollies.

The relief was rolled horizontally into the gallery and a forklift, in combination with manpower, lifted the object to a vertical position. The conservators and art handlers carefully slid the assembled relief onto its gallery platform using two sheets of silicone Mylar placed beneath the object. The Mylar was removed and the bottom edge was leveled with recessed wooden shims. Two, 3/4" wide brass clips were placed on either side of the relief and screwed to the backboard to prevent the relief from falling forward should anyone accidentally bump into the case.

8. A Better Acryloid B-72 Fill Material

A paste comprised of Acryloid B-72, fumed silica and cellulose powder was also used to fill losses along the cracks and on the sides of the relief where the staples had been removed (Fig. 14). This paste mixture has unique properties that make it particularly versatile. The combination of Acryloid B-72 and fumed silica or microballoons is not novel. When only these two materials are used, however, the mixture can be very sticky, stringy and difficult to apply. It shrinks no matter how viscous a solution of Acryloid B-72 is used, and the fill material remains soft and spongy for many days.

If cellulose powder is added to a mixture of Acryloid B-72 in acetone and fumed silica, however, all of the above problems are eliminated: the paste is very thick and cohesive, so one can grab a small amount out of the jar and place the material on the surface without pulling along strings of adhesive with the spatula. It does not shrink. It dries hard, not spongy, which makes carving, sanding and texturing an easy task. The dried fill material is strong yet light, and it can be easily re-softened, manipulated and shaped with the application of solvents or heat.

The paste is made by dampening 40 grams of cellulose powder with acetone, adding only enough solvent to wet the fibers, not make a liquid. Next, add 60 milliliters of 20% Acryloid B-72 in acetone and mix well with a spatula; then add 3 grams of fumed silica and mix well again. The viscosity of the prepared paste can be adjusted by adding more or less of the Acryloid B-72 solution. When working with the paste, be sure to stir the mixture every now and again to prevent the Acryloid B-72 solution from rising to the top of the container.

The fills on the front of the relief were textured with small metal files to simulate the texture of the original sandstone. All fills were then inpainted with Liquitex acrylic paints (Fig. 15).

9. Conclusion

The techniques developed by the conservators can be easily adapted to almost any kind of dowel repair. There are, however, certain problems that must be addressed, especially for extremely large stone objects.

During the treatment of the stela, the silicone Mylar on the table top and on the underside of the pallets frequently tore. The tearing was probably due to the fact that only the edges of the Mylar were adhered with double-sided tape. Had the Mylar sheets been adhered along their entire surface with an adhesive, the tearing would have been minimized.

For especially large objects, a frictionless surface other than silicone Mylar should be considered. Silicone Mylar is available in rolls of a maximum width of approximately 1 meter. The Mylar cannot be overlapped when preparing the table or the underside of the pallets. Any overlapping causes tears in the Mylar when the pallets are moved. Therefore, for fragments wider than one meter, it is not practical to use the Mylar. In the future, the conservators intend to further refine these techniques by exploring the use of Teflon and high-density polypropylene instead of Mylar.

Acknowledgements

The authors would like to extend their gratitude to the staff of the Conservation Lab and the Collections Management crew of The Brooklyn Museum for their support during the treatments of the Stela and the Sarcophagus. Thanks also to Nicolas Economos, Michelle LiCalsi, and Kim Travis for their close involvement and contributions to these projects.

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Lisa Kronthal, American Museum of Natural History, Central Park West at 79th Street, NY 10024

Reference

The Brooklyn Museum Archives. 1939. Egyptian Department, The Brooklyn Museum, 200 Eastern Parkway, Brooklyn, NY, 11238, USA.

Sources of Materials

1. Acryloid B-72
Conservation Materials Ltd.,
1395 Greg St., Suite 110, P.O. Box 2884,
Sparks, NV, 89431, USA
telephone: (702)331-0582, 1-800-733-5283

2. Cab-O-Sil (fumed silica)
Cabot Corporation,
Cab-O-Sil Division,
Rt. 36 West,
Tuscola, IL, 61953-0188, USA
telephone: (217)253-3370

3. Cellulose Powder CF-11
Whatman Labsales,
P.O. Box 1359,
Hillsboro, OR, 97123-99892, USA
telephone: 1-800-942-8626

4. Double-Coated Tape (3M #415)
3M Center,
St Paul, MN 55144-1000, USA
telephone: (612)733-1110

Light Impressions
439 Monroe Ave.,
P.O. Box 940,
Rochester, NY 14603-0940
telephone: 1-800-828-6216

University Products, Inc.
517 Main Street,
P.O. Box 101,
Holyoke, MA 01041-0101

5. Hot-Melt Glue Sticks
3M Center,
St. Paul, MN, 55144-1000, USA
telephone: (612)733-1110

University Products, Inc.
517 Main Street,
P.O. Box 101,
Holyoke, MA 01041-0101

Conservation Support Systems
P.O. Box 91746,
Santa Barbara, CA 93190-1746
telephone: 1-800-482-6299

6. Liquitex Acrylic Paints
Binney & Smith Inc.,
Easton, PA, 18044-0431, USA

also available at most art supply stores

7. Masonite
available at most lumber yards.

8. Pliacre Epoxy Putty
Philadelphia Resins,
130 Commerce Drive,
Montgomeryville, PA, 18936, USA
telephone: (215)855-8450

9. Silicone-Coated Mylar
Conservation Materials Ltd.,
1395 Greg St., Suite 110, P.O. Box 2884,
Sparks, NV, 89431, USA
telephone: (702)331-0582, 1-800-723-5283

10. Stainless Steel Dowels
Small Parts Inc.,
13980 N.W. 58th Court, P.O. Box 4650,
Miami Lakes, FL, 33014
telephone: (305)557-8222

11. Volara (closed-cell polyethylene foam sheet)
Foam-Tex Inc.,
150 West 22nd Street,
New York, NY, 10011-2421, USA
telephone: (212)727-1780

University Products, Inc.
517 Main Street,
P.O. Box 101,
Holyoke, MA 01041-0101

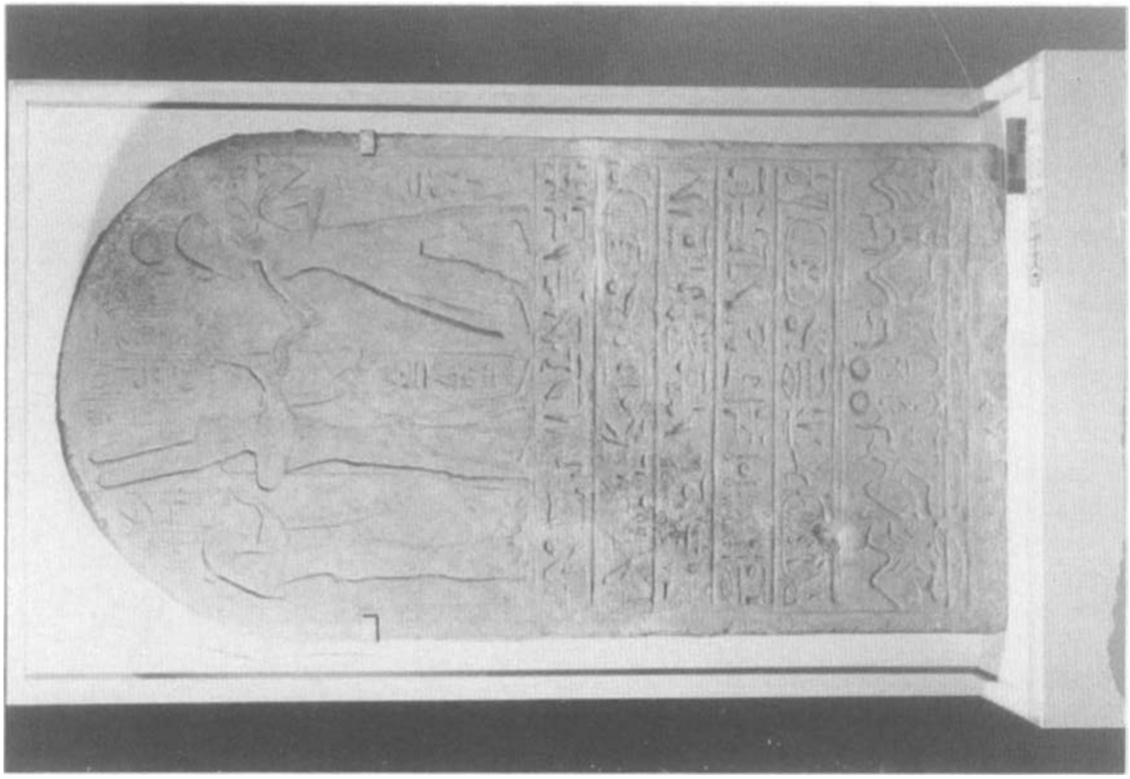

Figure 1. XIXth dynasty stela of Ramesses II, front view, before treatment.

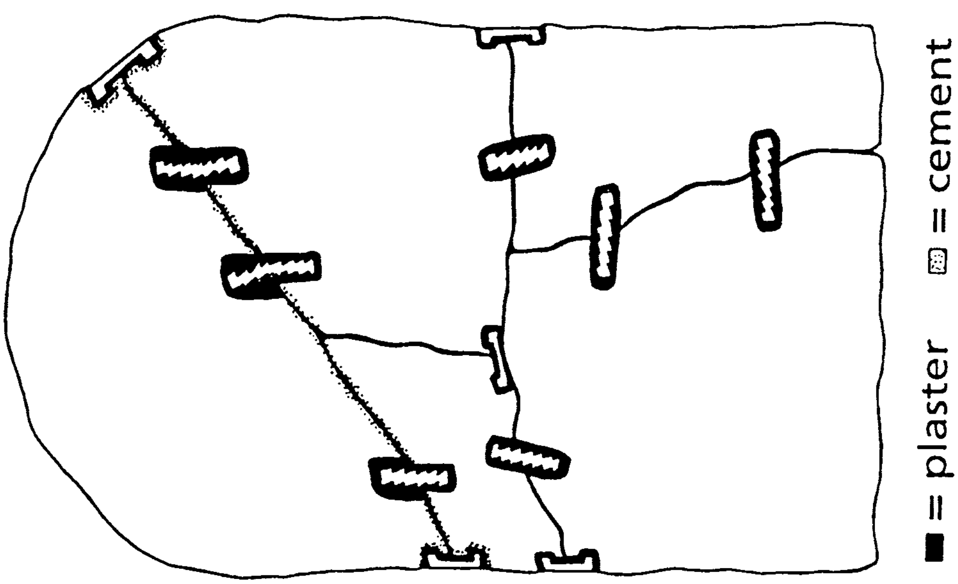

Figure 2. Diagram of stela, indicating location of old repairs.

Figure 3. Stela, during treatment, after removal of old fill materials.

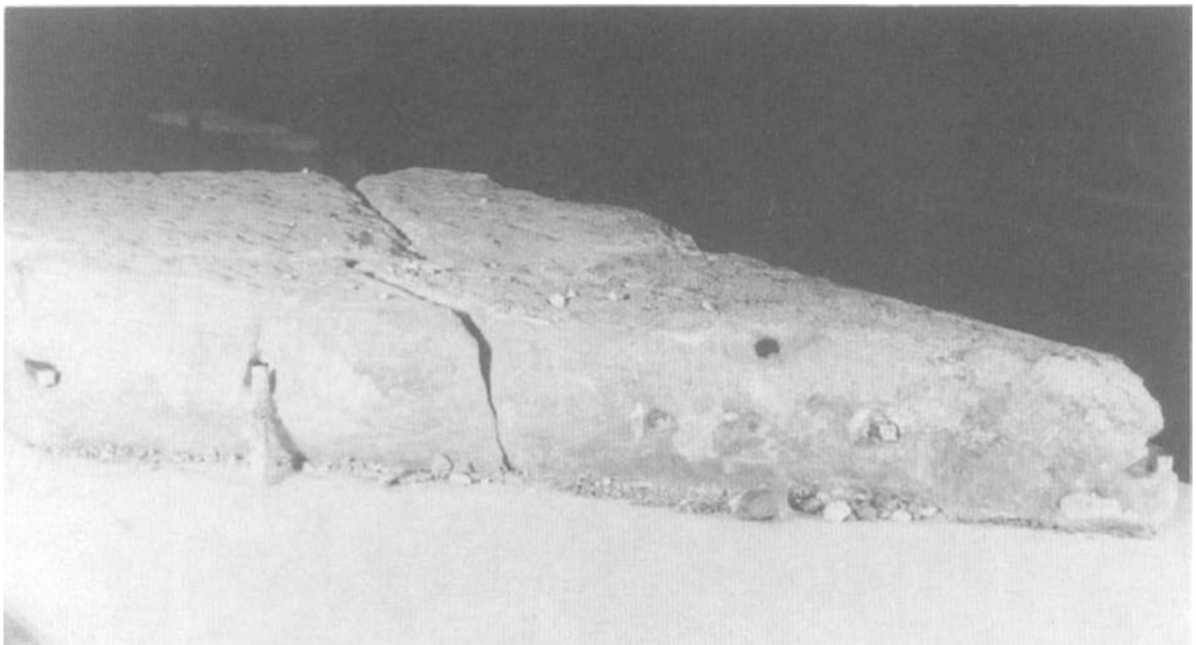

Figure 4. Stela, during treatment. The top, curved fragment is removed revealing notched copper dowels and staples used in the previous repair.

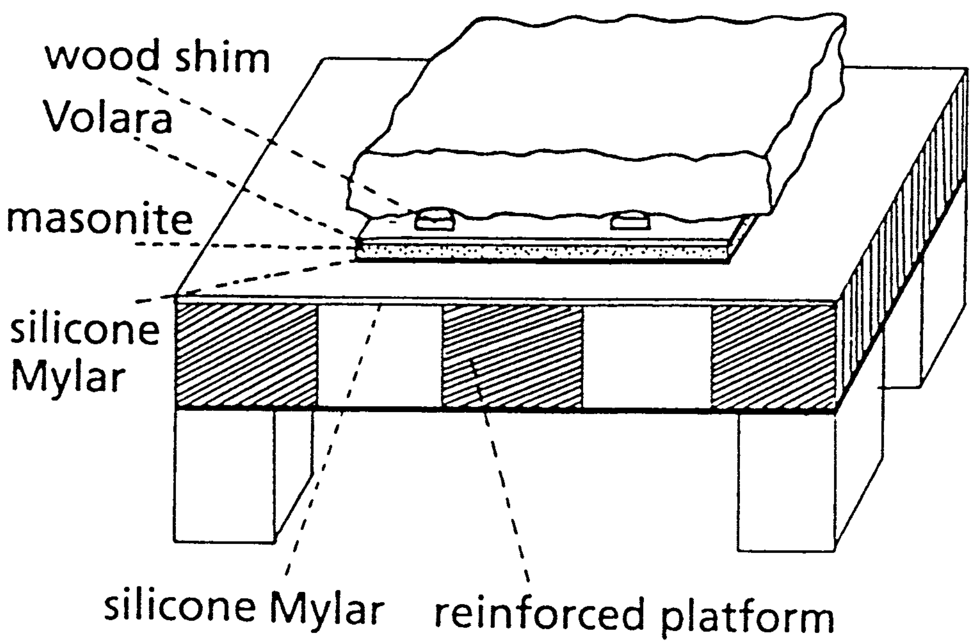

Figure 5. Diagram of pallet system developed for moving heavy fragments.

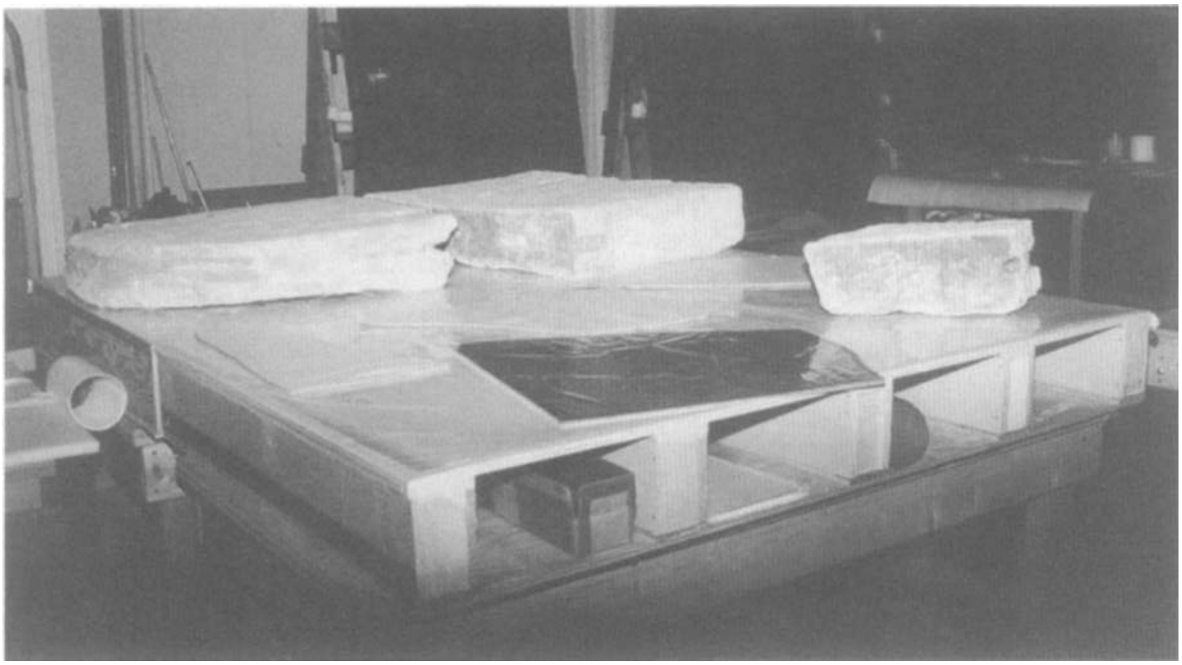

Figure 6. Pallets used for moving large stone fragments. Pallet in foreground is upside down, exposing silicon mylar underside. Remaining pallets show Volara padding onto which fragments were placed.

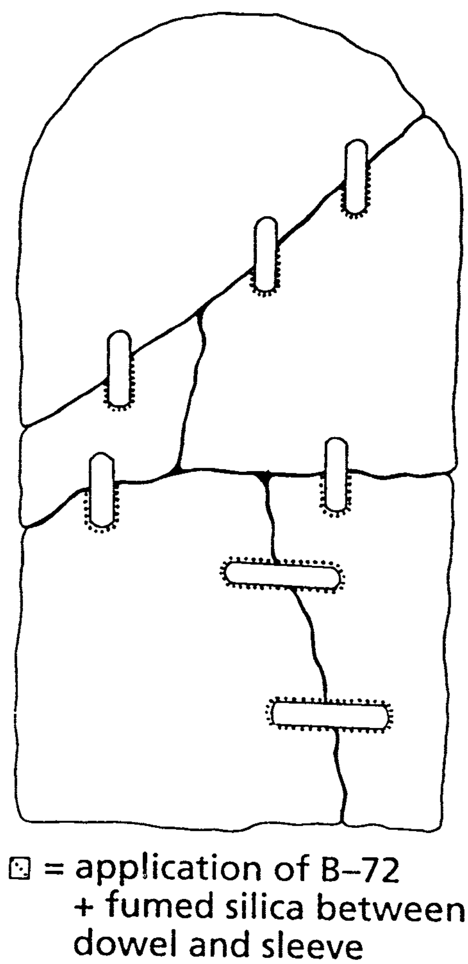

Figure 7. Diagram of stela indicating location of new dowels and application of adhesive.

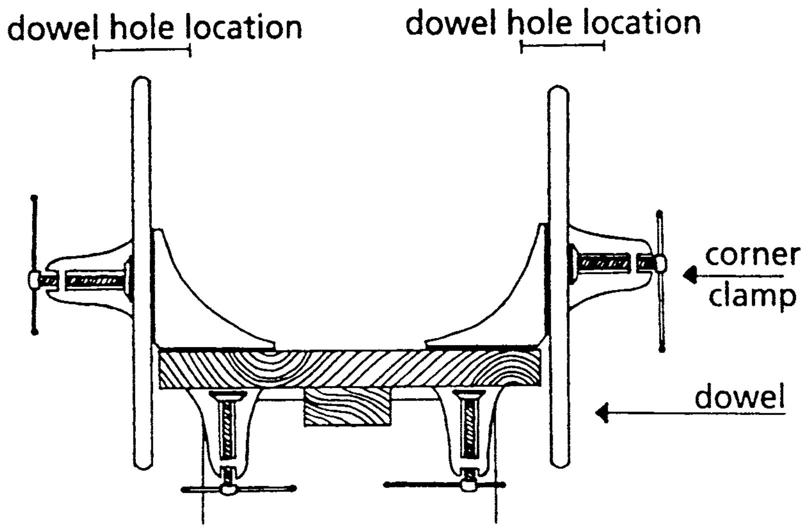

Figure 8. Simple rig for creating parallel dowel holes.

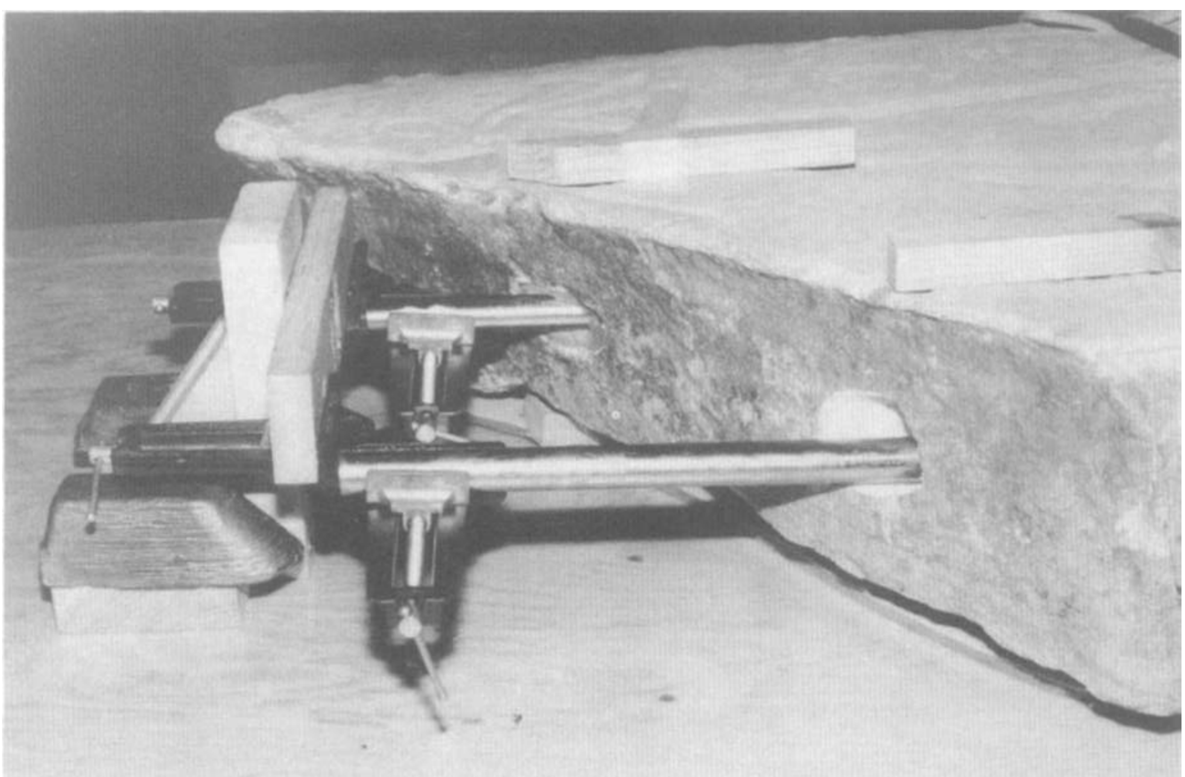

Figure 9. Simple rig with dowels in corresponding holes.

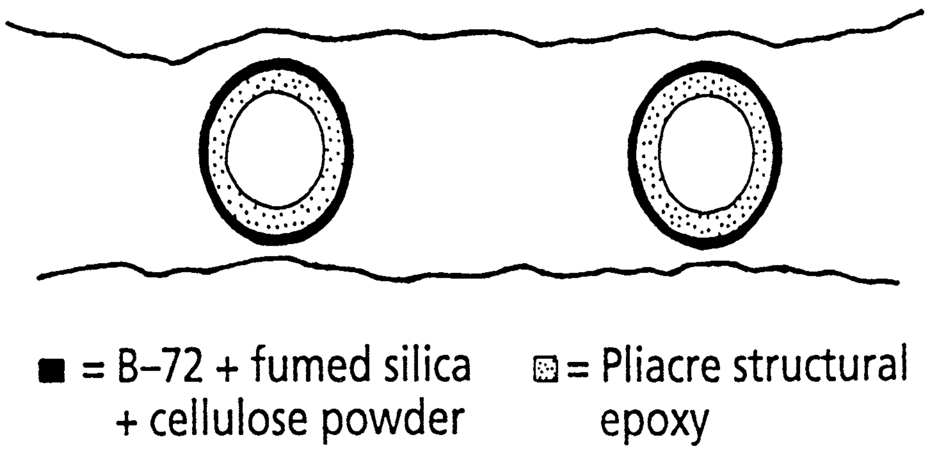

Figure 10. Stratigraphy of dowel hole interiors.

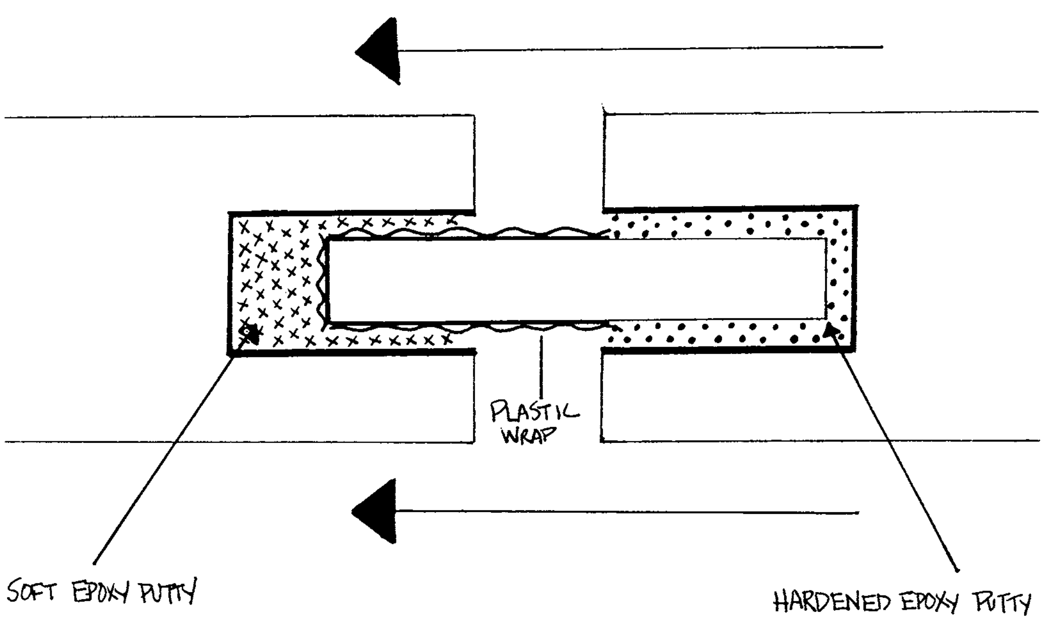

Figure 11. Diagram showing process for creating companion, parallel dowel sleeve.

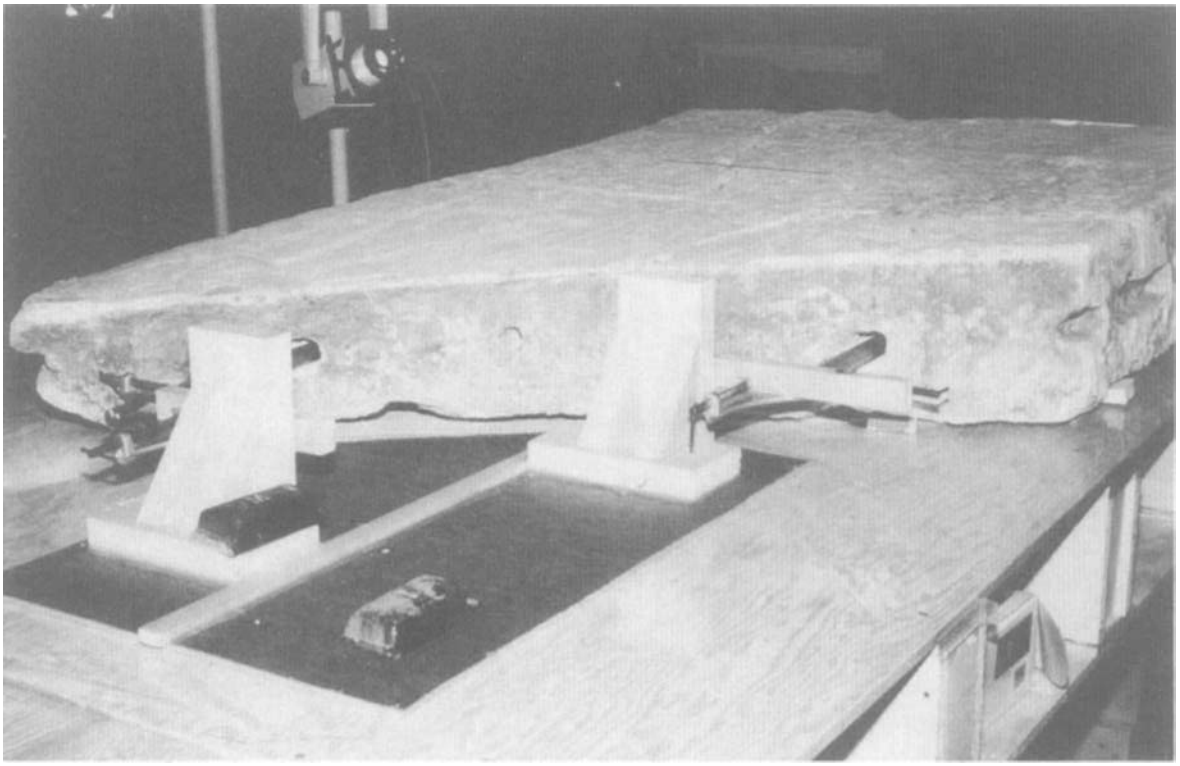

Figure 12. Modified rig for sharply angled break at top of stela.

Figure 13. Top break edge with parallel dowels in place.

Figure 14. Stela, during treatment, after filling losses.

Figure 15. Stela, after inpainting of fills.

STRUCTURAL TREATMENT OF A MONUMENTAL JAPANESE BRONZE EAGLE FROM THE MEIJI PERIOD

Marianne Russell-Marti and Robert F. Marti

Background

In 1935 the Kansas City developer, J. C. Nichols, installed a number of sculptures on the green strip on the Ward Parkway to create a "Mile of Art". This major installation, which included sculpture, stone fountains and architectural elements, was intended to add beauty and interest to the roadway, and to attract developers to the fine new neighborhoods being built in this area of Kansas City, Missouri (Nichols).

A focal point of the installation is a massive Japanese bronze eagle located on the Parkway at 67th Street (Figure 1). The sculpture is of the Meiji period, dating from the late 19th century to the early 20th century. The eagle measures 7 feet from beak to tail, has a wingspan of 14 feet, and rests on a 5-foot tall mountain/base. The total height from base to wingtip is approximately 14 feet. Little is known of the provenance of this sculpture. It was reportedly exhibited at the 1904 Saint Louis World's Fair (Nichols), but research into documents from the St. Louis Fair and other International Exhibitions[1] did not turn up any information on this particular sculpture. Certainly during the Meiji period a great deal of art was produced for export to the many International Exhibitions taking place all over the world, and it is possible that the eagle was one of these export pieces (Fairley 1991) [2].

The sculpture was originally constructed and assembled in separate sections, which included the eagle body, the head and neck, the wings, and the mountain/base. These sections were originally fitted together by means of mechanical attachments tied in to an internal structure. The bronze base, or mountain, was cast in numerous smaller sections which were later joined, in some areas successfully, in some areas not, by fusing adjoining edges with molten bronze (Gowland 1915, Stewart 1976). In the modeling before casting, and in engraved details on feathers after casting, great attention was originally given to surface finish to create a decorative and at the same time a life-like presence. There are four basic styles of feathers on the eagle. These include both high relief and low relief feathers modeled in place prior to casting, and individually cast feathers and feather groupings which were applied after the bird was cast.

By the time the sculpture was installed on the Parkway in 1935, the original internal armature had deteriorated to the condition where it was no longer functional, presenting the Kansas City workers with the difficult problems of holding the very heavy, extended shapes of the individual sections of the sculpture together, and of supporting the eagle on its base. The solution in 1935 was to fill the entire sculpture with concrete, and iron reinforcing rods (commonly referred to as rebar). The reinforced concrete did hold the eagle together for over 50 years, but it also caused severe damage to the sculpture, cracking and splitting the bronze through the action of freezing water on the interior.

We carried out conservation treatment on the sculpture from August of 1990 to November of 1991. While the treatment addressed all of the condition problems described below, this paper will focus on the design and construction of a new internal support system for the sculpture. During all aspects of our treatment, decisions and solutions were based on the fact that the sculpture was going to be returned to the same outdoor environment it had been in for over 50 years, susceptible to the same wind and weather conditions, pollution, and the ever-constant potential of physical contact by the public.

Condition

The condition problems of the sculpture included the general loss of its original structural support system, problems related to previous repairs, missing parts, and corrosion of the bronze from being in an aggressive outdoor environment.

The combination of loss of structural integrity, a number of original casting flaws, and the presence of the concrete resulted in an extensive system of breaks and cracks running throughout the eagle and the base. In some areas the crack systems ran through or across design elements (Figures 2 and 3). In many areas on the sculpture, the expanding ice had caused splitting along previous casting flaws, or "cold shuts", where the cast molten metal solidified before it could flow to fill an entire area and make it one cohesive unit of bronze. These areas had been masked at the foundry by soldering bronze feathers over the gaps, but had opened up due to freeze/thaw cycles subsequent to the sculpture being filled with concrete.

Previous repairs also accounted for aesthetic problems and damages. Large hex-head bronze bolts had been used to help hold the wings on and to strengthen ankle joints (Figure 4). These contrasted with the otherwise naturalistic appearance of the eagle. A number of detached sculptural elements, joints, and breaks had been repaired by welding. The welding was generally unsuccessful, often without proper bonding of the metal. Many of the welded areas had been roughly ground down using a grinding tool. Grinding had obliterated sculptural detail on the front planes of the wings.

There were a number of missing parts and damaged areas on the sculpture. Losses included the decorative copper alloy insert in the left eye, and major damage to the insert in the right eye. The area underneath the tail was extensively damaged, missing most of the individual feathers and feather groupings. Many other feathers were missing throughout the sculpture, and a number of cast bronze vine leaves were missing from the base. Like many of the feathers, the vine leaves had been cast individually and applied to the base after it was finished, by means of copper rivet-like pins. Only about three leaves and fragments remained on the sculpture, the locations of the others indicated only by a number of small round holes.

While the sculptures are located in a well-to-do residential neighborhood, the Ward Parkway has become a major thoroughfare through Kansas City, with heavy automobile traffic day and night. As a result, the bronze had undergone deterioration from corrosion activity, resulting in pitting and loss of metal. The green and black corrosion products were visually disfiguring, were voluminous in some areas and camouflaged sculptural detail, and presented a very different appearance than the colorful and often naturalistic patinas generally associated with figurative sculpture of the Meiji period. Careful excavation through the layers of corrosion products under magnification did not reveal areas which we considered to be remnants of original patination [3].

Disassembly and Notes on Construction and Composition

The first stage of treatment was disassembly and removal of the sculpture to our workshop. The eagle was dismantled according to its original construction, at original joints. Disassembly, along with the removal of the nearly solid core of concrete from the interior of the sculpture, revealed additional information on the construction of the eagle and of the mountain/base.

The head and neck had been cast as one piece, and was attached to the body by eight tapered pins inserted through drilled holes in the feathers at the base of the neck. These connections held the head firmly, but did not provide sufficient overall support.

Removal of the head and neck revealed the extensive use of rebar from the 1935 repair inside the body cavity and wings. The rebar was of several different sizes, ranging from 1/2 inch round to 1 1/4 inches square. The rebar originated in the body cavity, and extended approximately one-third of the distance into the wings. The areas surrounding the rebar had been entirely filled with concrete.

The rebar was cut with a torch to allow removal of the wings. The wings are constructed to slide into receiving slots in the body cavity. The overlap of the wing base inside the body was probably originally secured by means of four bronze pins inserted through drilled holes in the wings and the shoulders. These pins had subsequently been replaced with the large bolts and nuts, probably dating from the 1935 repair. After much of the concrete was cleared from the wing cavities, a very deteriorated and apparently original wrought iron armature was found (Figure 12). The shape of the armatures is a general S shape, attached to the interior of the wing near its far end and to the interior of the body at the other end. The original anchoring system to the interior of the body was no longer evident. Conforming to the contour of the wing, the S shape allows for gentle compression and stretching of the armature with the up and down movement in a wind.

After the wings were removed, the body was lifted off of the base along the original joint of the ankles to the feet (the feet are cast as an integral unit with the top of the base). The eagle probably was originally supported on its mountaintop by two tapered bronze and iron extensions which were inserted into the feet, and likely would have been attached to a support structure inside the base. In cross section these extensions have a core of iron surrounded by cast bronze, indicating that the bronze was poured with the iron rods already in place. While the iron had almost completely deteriorated, the four-inch long bronze extensions remained at the ends of the legs. No trace of an original support for the eagle body remained in the mountain itself.

The mountain/base had to be cut along original joints in order to allow its disassembly. The bronze mountain was in extremely poor fragmented condition, with large areas of loss which had been bridged by the solid mound of concrete present on the interior (Figure 5). The foundry work on the base was very inconsistent. There were sections where the casting was flawless, of thickness slightly less than 1/4 inch, adjacent to sections riddled with cold shuts and ranging in thicknesses from 1/16 inch to over 1/2 inch.

Following disassembly, the concrete remaining inside the sculpture was removed using a 20 lb. electric hammer. It required one person working for five days to clear the interior of the sculpture. As the concrete was removed, large amounts of black core material were found adhered to the sides of the interior. The core material was a dense conglomeration of what appeared to be a natural cereal grain with tiny 1 mm "pebbles" embedded within the mass [4].

Prior to beginning structural work, metal samples were analyzed by Inductively-Coupled Plasma (ICP). The three principal components of the bronze were found to be the following: Copper 73%, Lead 15%, and Tin 5.5% [5]. The alloy corresponds closely with a Japanese art bronze alloy *karakane*, in which the proportions of copper may range from 71 to 80 %, of tin from 2 to 8%, and of lead from 5 to 15% (Gowland 1915).

The high level of lead in the alloy is credited with giving *karakane* the following desirable characteristics: low melting point, excellent flow properties when melted, capability of reproducing fine and sharp surface details, low shrinkage upon solidification, smooth surfaces, and capability of receiving rich and varied patinas (Gowland 1896). The high amount of lead is also responsible for the extreme brittleness of this alloy, its chief disadvantage[6]. Brittleness occurs because the lead is not fully dissolved in the alloy, but instead sits in the bronze as a separate phase. Excavation of the bronze under magnification, or even a look at a break edge on the eagle, showed shiny, distinct, soft chunks of lead embedded within the matrix.

Treatment: Construction of a New Internal Support System

Of primary consideration in the structural work was the need to give stability to the heavy and extended forms of the eagle. The eagle weighs approximately 800 pounds including the two wings, each of which weighs upwards of 200 pounds. The extreme thinness, faults and damages found in sections throughout the mountain/base meant that it could not function in a load-bearing capacity.

An internal support system was designed to solve these problems of holding together the various components of the eagle, and of supporting the eagle on its base. Based on our observations of the remains of the original structure, the original design of the bird's construction and support system was well-conceived, simple and elegant. We therefore tried to use and adapt these same concepts as we carried out the structural aspect of the treatment, but with different materials. We also retained the system of keeping the eagle in distinct sections, allowing for disassembly in the future.

Other aspects of treatment were taking place simultaneously with the structural work, and are briefly described below. However, the repair of the extensive damage to the original fabric of the sculpture -- closing cracks and cold shuts and filling losses -- was an integral part of the structural treatment, in that the individual components of the sculpture -- the base, the head and neck, and the body -- needed to have structural integrity themselves in order to be successfully incorporated within an overall structural system.

Prior to beginning work, we consulted the Copper Development Association (CDA)[7] for advice on which alloys would be best for construction of the armatures, for welding and for repairs. For structural purposes, the metal needed to be of the proper composition and dimensions to offer sufficient strength, yet not add excessive weight to the sculpture as a whole. For welding and patching, the alloy needed to be of the right composition to blend with the old when chemically patinated, and in all applications new metal needed to be chosen which would not promote corrosion through galvanic activity between adjacent new and original sections.

A tower was constructed inside the base, designed in such a way as to support the eagle independently of the base's bronze skin (Figure 6). Square tubing (0.049 inches thick) of a copper-zinc alloy (called red brass) was used for the tower, chosen because it is strong and lightweight. The support structure rises inside the base, ending just short of the top of the mountain. The tower welded to the interior wall of the base at the top and at the bottom. A number of additional attachments were made in the lower third area of the mountain, making the tower and the base an integral unit, and giving added structure to the inherently fragile base (Figure 7). When assembled on site, the mountain is anchored with bronze bolts to a stone and concrete pedestal.

Two round brass tubes or sleeves were incorporated into the upper configuration of the tower to receive the structural support system for the eagle body (Figure 8). Aluminum-nickel bronze rods were welded into the bronze extensions at the ends of the legs, replacing the deteriorated iron rods (Figure 9). When the sculpture is assembled, these new extensions pass through the openings in the bird's feet on top of the mountain and slide into the brass tubes in the top of the new structural tower inside the base. The rods, designated C630 [8], are one inch in diameter. We used this stock because of its high tensile strength, comparable to mild steel yet more compatible with the original fabric of the sculpture. When the two parallel rods are in place in the receiving sleeves of the base, no additional anchoring is required.

The welding wire used throughout the project was designated AWS A5.7 [9], 0.030 inches in diameter. The CDA advised us to match the tin content of the eagle and that of the welding wire as closely as possible in order to achieve a good color match when repaired areas were repatinated. Welding of the eagle sculpture proved to be extremely difficult because of the high lead content of the bronze. Throughout the project we were very fortunate to work with Walter Breidenbach, a welder with over 30 years' experience, who had the skill, the interest and the patience to successfully weld this very difficult material.

An internal support structure was welded inside the eagle's body and in the neck (Figures 10 and 11). The same lightweight square tubing used inside the mountain was used inside the eagle. The head/neck assembly was fitted with a brass extension which slides into a receiving slot built into the body armature. The neck is further secured by eight tapered brass pins, using the same holes as the original system.

Access panels were cut into the underside of the outermost areas of the wings, to allow removal of the deteriorated original wrought iron armatures. Aluminum-nickel bronze rods, one inch in diameter, were welded inside each wing at one end, at the same locations as the connections of the original rods (Figure 12). The new rods were shaped to the same S conformation as the originals. The access panels were put back in place by welding. The free ends of the new rods were threaded, and slide into a receiving section in the eagle body armature (Figure 13). They are drawn into a snug fit and secured with brass nuts. The wings are further secured to the body with tapered bronze pins at the shoulders, replacing the large nuts and bolts (Figure 14).

The entire sculpture can readily be disassembled in the future when necessary. This would be accomplished by 1) removing the pins around the eagle's neck, 2) sliding the head/neck assembly out of the interior body armature, giving access to the interior of the sculpture, 3) unbolting the wings from the body armature and removing the pins at the shoulders, followed by removal of the wings, 4) lifting the eagle body up out of the armature inside the base, and 5) unscrewing the bolts out of the top of the pedestal, to release the mountain from its anchoring. The weight of the entire new armature is less than 200 pounds.

Summary of Additional Treatment Steps

Repairs

Extensive repairs were carried out on all of the sections of the sculpture. Repairs included patching holes and casting flaws, and welding sections of the sculpture back together. All patches were put in place by welding. The patch material was 1/16 inch sheet, copper alloy designation C510, phosphor bronze. It was chosen because the copper, tin and the zinc content of this alloy were the closest to the copper, tin and zinc content of the sculpture[10]. Repair work included approximately 500 hours of welding, and nearly 1,500 hours of chasing, or finishing, the welds.

Replacement of Missing Parts

New eyes, numerous missing feathers, and leaves on the base were made for the sculpture. The eyes were reconstructed according to the typical Meiji design of inset gold eyes with a dark pupil (Fairley 1991, Gowland 1915)[11]. Based on the fragment of the insert remaining in the eagle's right eye, it was clear that the eyes were of this configuration.

The duplication of missing feathers was generally straightforward, as most losses were within areas of a repeating design motif. In these areas replacement parts were made to match the basic design of the surrounding feathers. Feathers and leaves were cast in bronze, using molds taken of several original feathers and leaves on the sculpture. In some areas, feathers larger than the repeating feather motifs needed to be made. These were constructed using the C510 sheet bronze. The missing feather grouping underneath the tail was almost entirely reconstructed with the new cast bronze feathers, using evidence of the original configuration of the tail as a guide (there were traces of solder indicating where feathers had been placed). As a deterrent to vandalism, the new feathers and leaves were secured to the sculpture by means of plug welding. There were several areas on the eagle where we did not feel confident in replacing losses, as there was no clear indication of what the design could have been.

Surface Treatment

In areas where a brown oxide layer was found, the overlying green corrosion products were removed from the bronze using a 50:50 mixture of ground walnut shells (60/100 mesh) and glass beads (140 mesh) at 35-40 p.s.i.. A 30:70 mixture of walnut shells to glass beads, at 50 p.s.i., was used to remove corrosion products where no brown oxide layer was present.

The sculpture was patinated using heat applied by torch, and dilute solutions of cupric nitrate and ferric nitrate. Where it existed, the brown oxide layer was incorporated into the new patina. As no documentation could be found describing the appearance of the sculpture prior to surface deterioration, the coloration of the patina was based on other Meiji bronzes, especially sculptures of eagles.

After traces of patination chemicals were rinsed from the bronze with water, the sculpture was given several spray applications of the protective coating Incralac[12]. Some areas of patina were adjusted with thin applications of pigmented wax, followed by another spray application of Incralac.

Final Comments

The eagle was reinstalled on the Ward Parkway in time for a rededication ceremony on November 11, 1991. The instability of the sculpture, and the extensive damages, required a course of treatment more involved than is generally needed for outdoor bronze sculpture, and the extent of obviously missing design elements called for a high amount of restoration. Still, more work could have been done on the eagle, especially in the reconstruction of missing parts. Perhaps further historical research will turn up additional information on this sculpture to aid in a more complete reconstruction. However, the treatment has given stability to an otherwise unstable, even precarious sculpture, and the restoration of some of the losses allows the eagle to be experienced as an intact representation of the wonderful sculpture of the Meiji period.

Acknowledgments

Many people helped us in all aspects of this treatment. Our heartfelt thanks and admiration goes to Walter Breidenbach, our welder, without whom the project might not have been possible. We are very grateful to Dr. Daniel Kremser, of the Department of Earth and Planetary Sciences at Washington University, for arranging the ICP analysis, and to Dr. Leon Stodulski of the Detroit Institute of Arts and Dr. Bill Blanchard (formerly of the DIA) for analysis of the corrosion products. Many thanks to Dr. Carl Dralle and other corrosion engineers at the Copper Development Association, for their invaluable help in the structural issues, including review of our proposed solutions, and suggestions for materials. We are grateful to Mr. Emil Schnorr of the G.W.V. Smith Art Museum, for referring us to the writing of W. Gowland. A very special thanks to Mary Kastens, for her creative and untiring research into this sculpture and the art of the Meiji period. We would like to acknowledge our clients, the City of Kansas City Departments of Parks and Boulevards, especially Mr. R. Peter Loughlin, Landscape Architect, for providing support and working with us closely in all aspects of the work. And many thanks to Andrew Breidenbach, Clyde Adams, and Francis Marti, for long and cheerful hours of "hands on" work throughout the project.

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Nichols. undated. Unpublished scrapbooks of the J.C. Nichols Company. Volume 12, numbers 234-38 included a brief 1935 newspaper clipping and the minutes of a meeting regarding the donation of the eagle. The scrapbooks are stored at the University Archives, University of Missouri -Kansas City, Newcomb Hall, Room 302, 5100 Rockhill Road, Kansas City, Missouri 64110-2499.

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Endnotes

1. Photographs and catalogs from the following international Exhibitions were searched: 1) the 1876 Philadelphia Exposition, 2) the 1893 Columbia Exhibition in Chicago, and 3) the 1904 St. Louis World's Fair.

2. Besides the documented artwork displayed at the exhibitions, a number of sculptures were created for use as architectural ornaments at the elaborate fairgrounds. These were later sold off after the exhibitions closed. It is possible that the Kansas City eagle was such a piece. (Personal communication with Mr. Francis Caro, Jr.)

3. Samples of green, red, and black corrosion products were taken from several areas of the sculpture and sent for analysis by Dr. Leon Stodulski at the Detroit Institute of Art. A discussion of the analysis is not within the scope of this paper, but interested parties are encouraged to contact the authors for more information.

4. The core material has not been identified by analytical methods, but was readily recognized by Mr. Takuya Kosugi, a Japanese metal artist knowledgeable in traditional metal working techniques. Mr. Kosugi identified the grains in the mixture as rice husks, a traditional agent in core material mixtures.

5. The complete analysis of two samples is the following (the analysis was carried out by Dr. Ted Huston at the University of Michigan):

	Sample from Base	Sample of Feather
Zn	2.3	0.53
Cu	73.5	72.7
Pb	14.3	15.0
Sn	5.6	5.4
As	0.6	0.40
Fe	0.35	0.15
Ni	0.15	0.14
Sb	less than 0.05	0.65
Ag	0.07	0.02
	96.5	95.0

.6. Gowland discusses the brittleness of items cast from *karakane* as follows: "They are often low in tenacity, and offer but little resistance to bending and torsion when compared with simple copper-tin bronzes, ... Their use is hence almost limited to the production of objects of art. And even for those art castings, such as, for example, large equestrian or other statues, where a considerable strain has to be borne by certain parts, their use is inadvisable. ...I do not think they could be advantageously used for statues or monuments exposed to the weather in the impure atmosphere of our great towns, but for castings protected from these combined adverse influences I think the Japanese bronze "karakane" is worthy of a trial." (Gowland 1896, p. 645)

7. Copper Development Association Inc., 260 Madison Avenue, New York, New York, 10016, (212) 251-7200.

8. The composition of C630 is Cu 82%, Al 9.5%, Fe 2.5%, Ni 5.0% and Mn 1%.

9. The composition of AWS A5.7 is Cu 95.87%, Sn 4.0%, P 0.10 %, Al 0.01%, and Pb 0.02%.

10. The composition of C510 is Cu 83.7%, Sn 5.0 %, Zn 0.3 %, Pb 0.1%, P 0.05%. It was not an issue to match the lead content of the sculpture, as the high amount of lead is not truly part of the alloy.

11. Meiji eyes of this style were composed of gold foil over a copper alloy inset, with a central pupil of *shakudo*. *Shakudo* is a copper alloy containing silver and approximately 4% gold. It is used because it acquires a distinct and beautiful blackish color when patinated.

12. Incralac is a proprietary coating developed for use on copper alloys, containing Acryloid B-44 (Rohm and Haas) and the corrosion inhibitor benzotriazole. Available from Stan Chem, East Berlin, CT (203) 828-0571.

Figure 1. General view of sculpture *in situ*, before treatment.

Figure 2. Detail of proper left side of neck, showing the extensive cracking and breaking of bronze due to ice formation. The concrete used in the 1935 repair is visible on the interior of the neck.

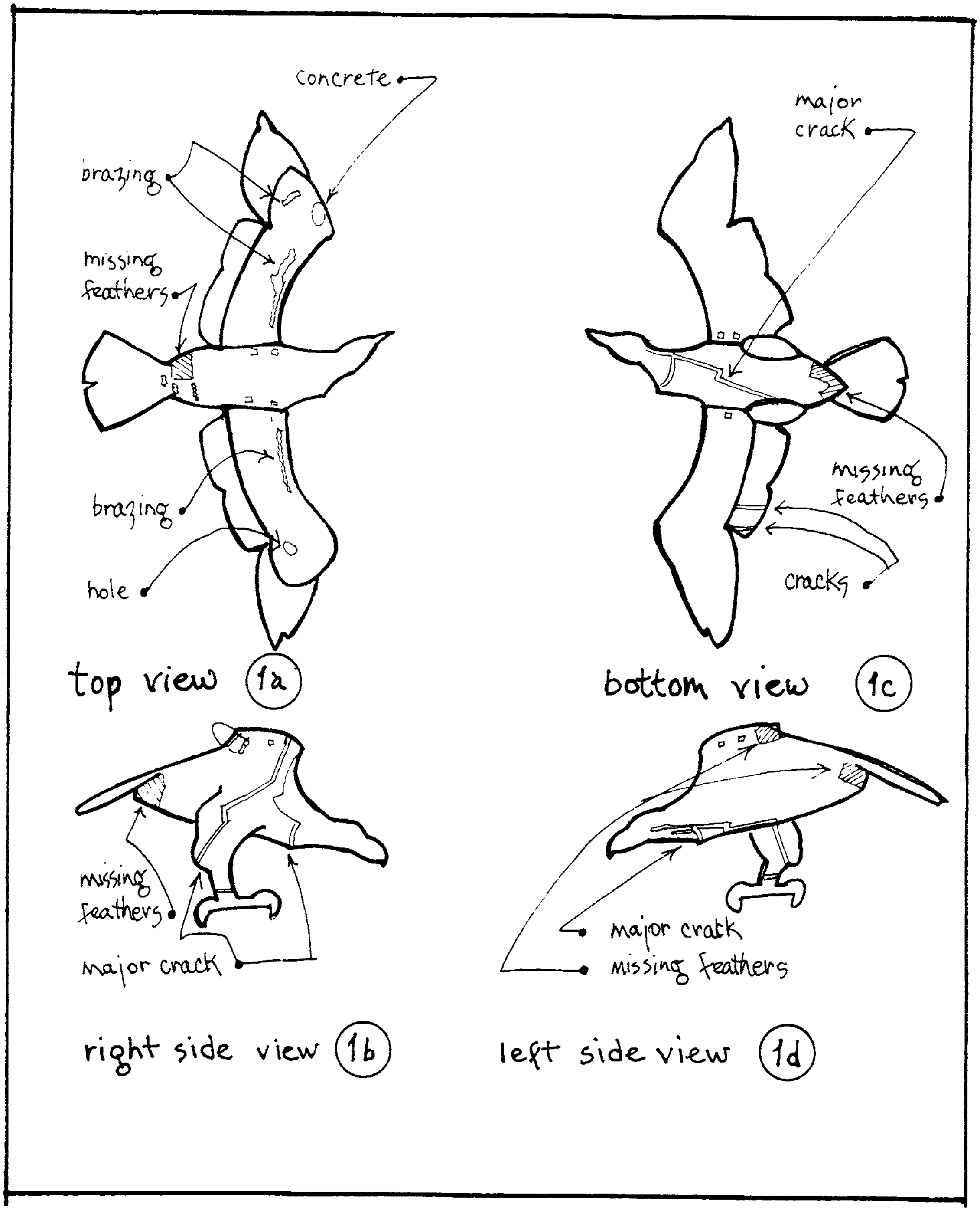

Figure 3. Diagram used in our initial Examination Report and Treatment Proposal (April 2, 1990), showing the crack systems and other damages to the eagle.

Figure 4. Detail, front view of eagle before treatment. Note the large bolts at the shoulders, and the icicle hanging from the proper left wing. The eye insert is also damaged and incomplete

Figure 5. Section of mountain/base, during removal of the concrete. The base is lying on its side, bottom towards the right.

Figure 6. Middle section of new tower inside mountain/base. The upper section of the mountain is being lowered over the tower.

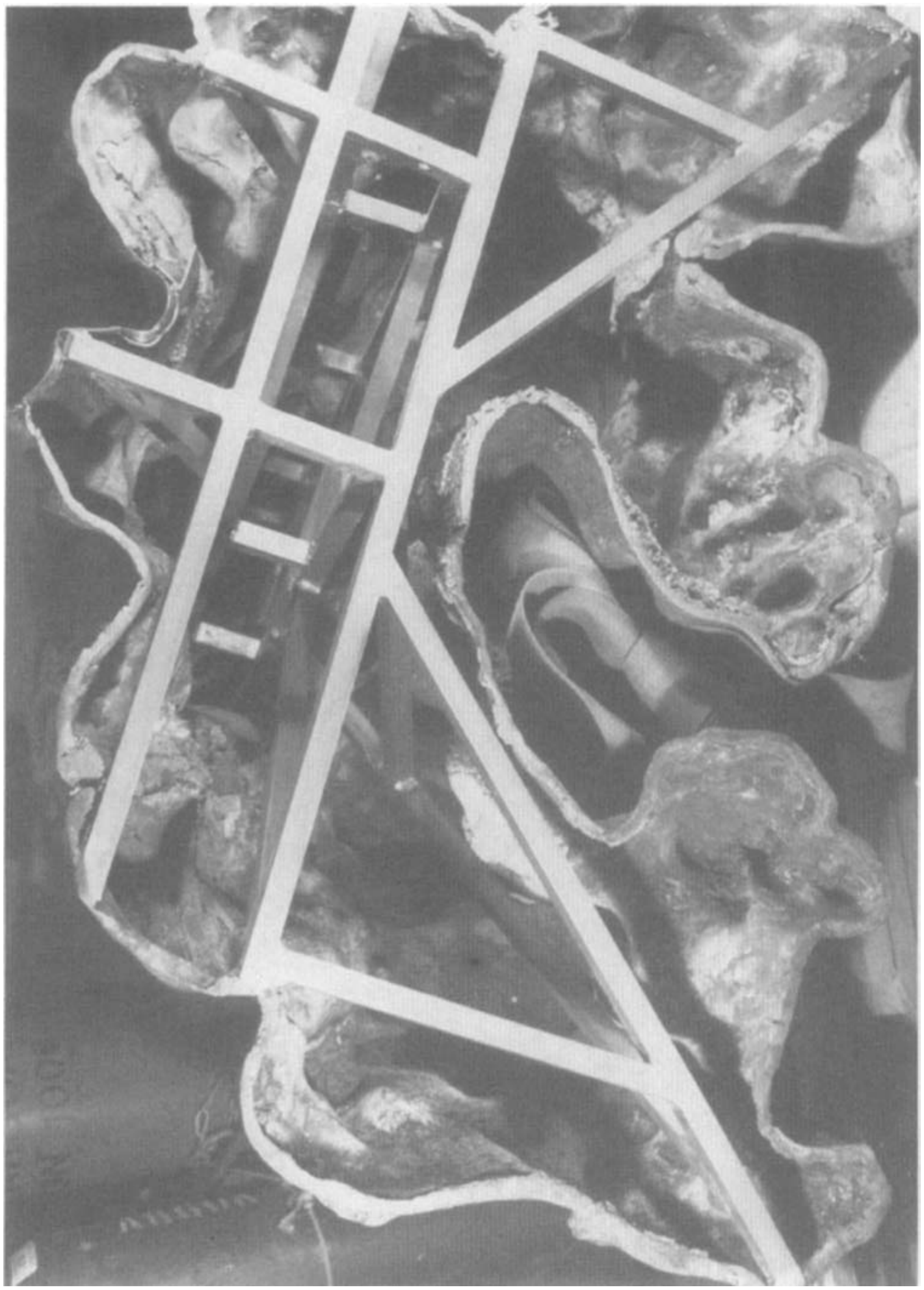

Figure 7. Interior support structure, looking up from the bottom of the mountain/base.

Figure 8. Detail of the support structure, looking up from bottom; shows one of the brass tubes welded into the tower, to receive the leg extensions of the eagle body. The tube is lined up with the opening in the bird's feet at the top of the mountain.

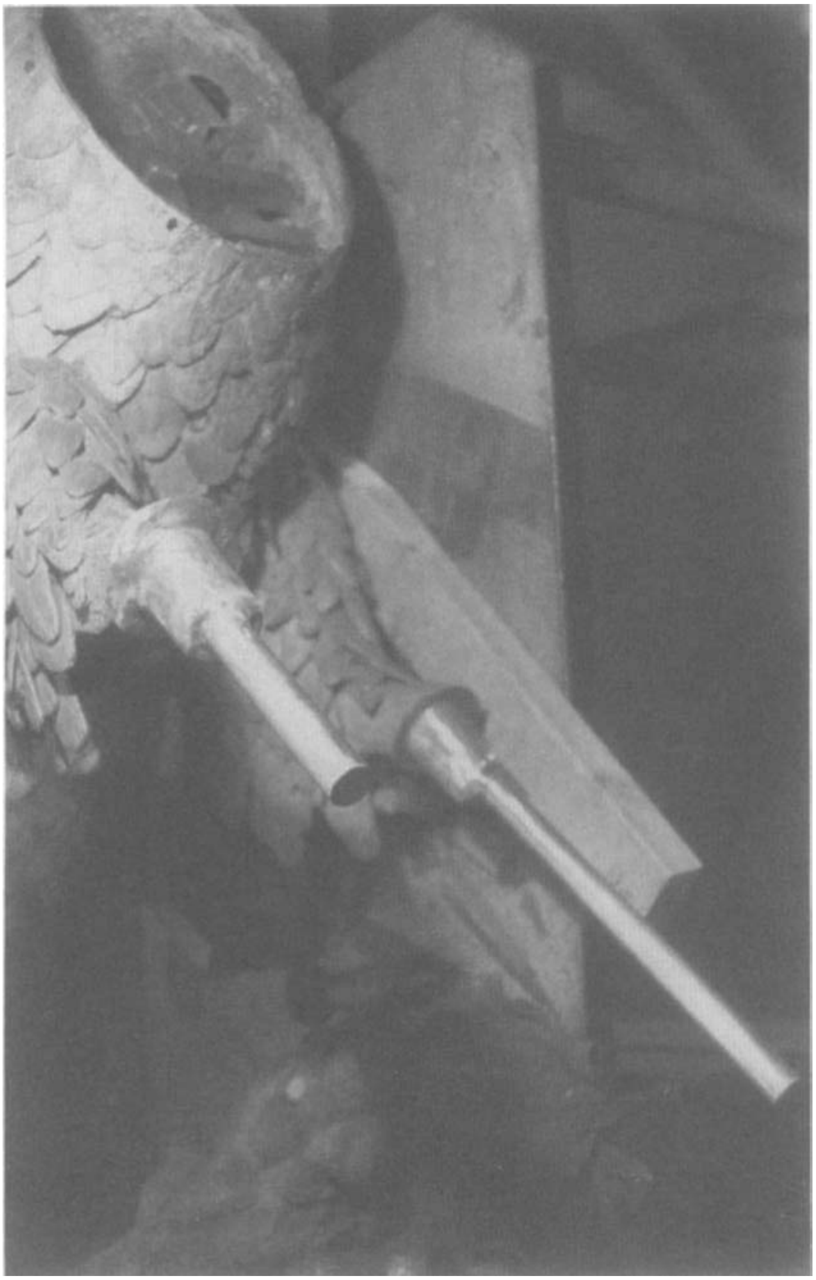

Figure 9. New bronze rods welded into the original extensions on the eagle's legs.

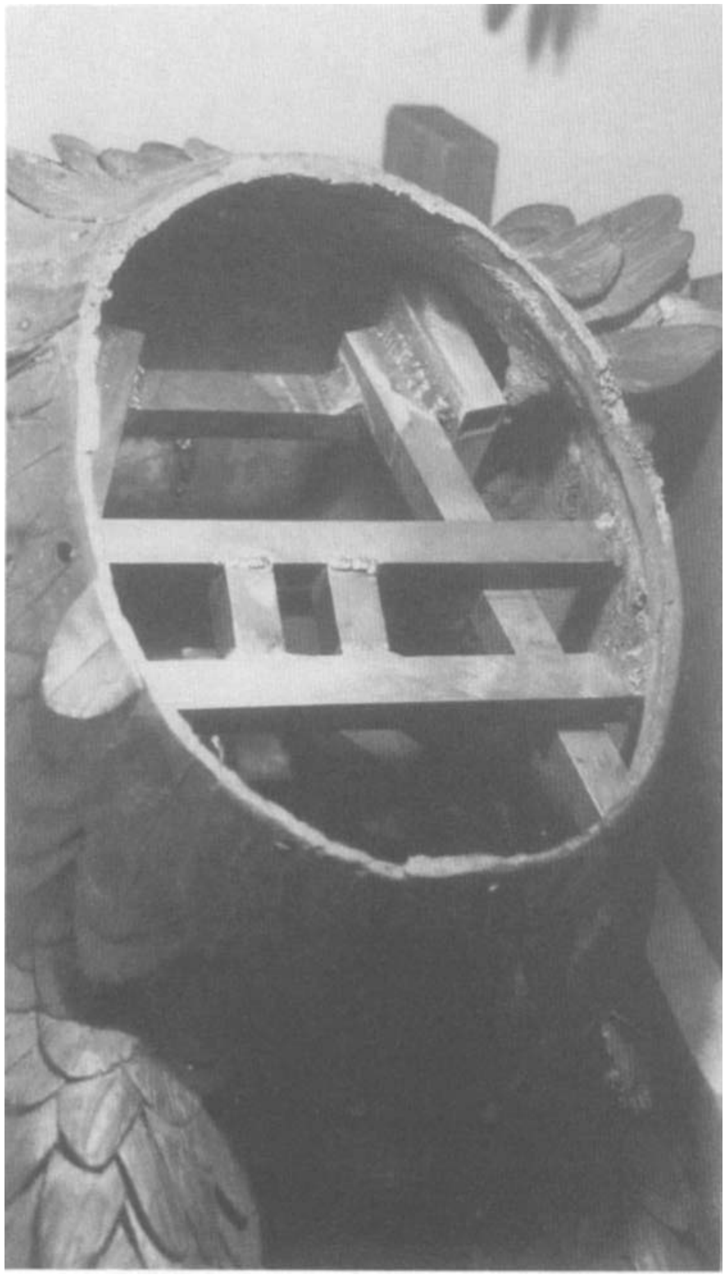

Figure 10. Support structure inside the eagle's body, designed to hold the head/neck and the wing armatures.

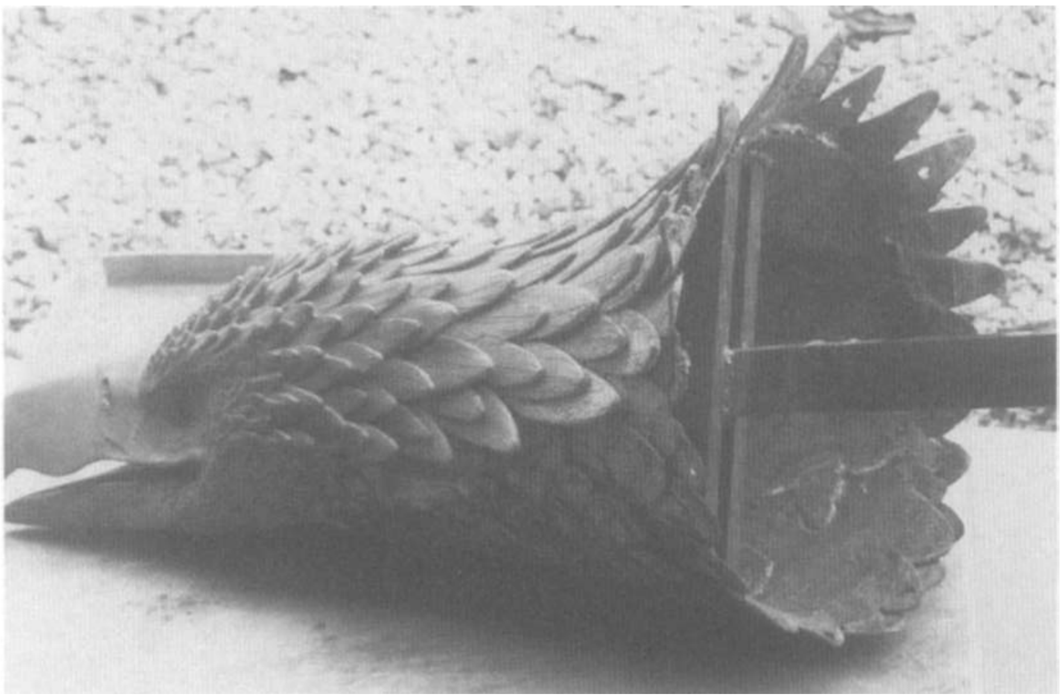

Figure 11. Support structure and extension inside eagle's head/neck. (Also refer to Fig. 14 for a more complete depiction of the configuration of the head/neck armature.)

Figure 12. Detail of wing with access panel cut out. The original wrought iron armature is shown lying on the outside of the wing. The new wing armature is visible on the interior, welded at one end, in the same location as the previous armature.

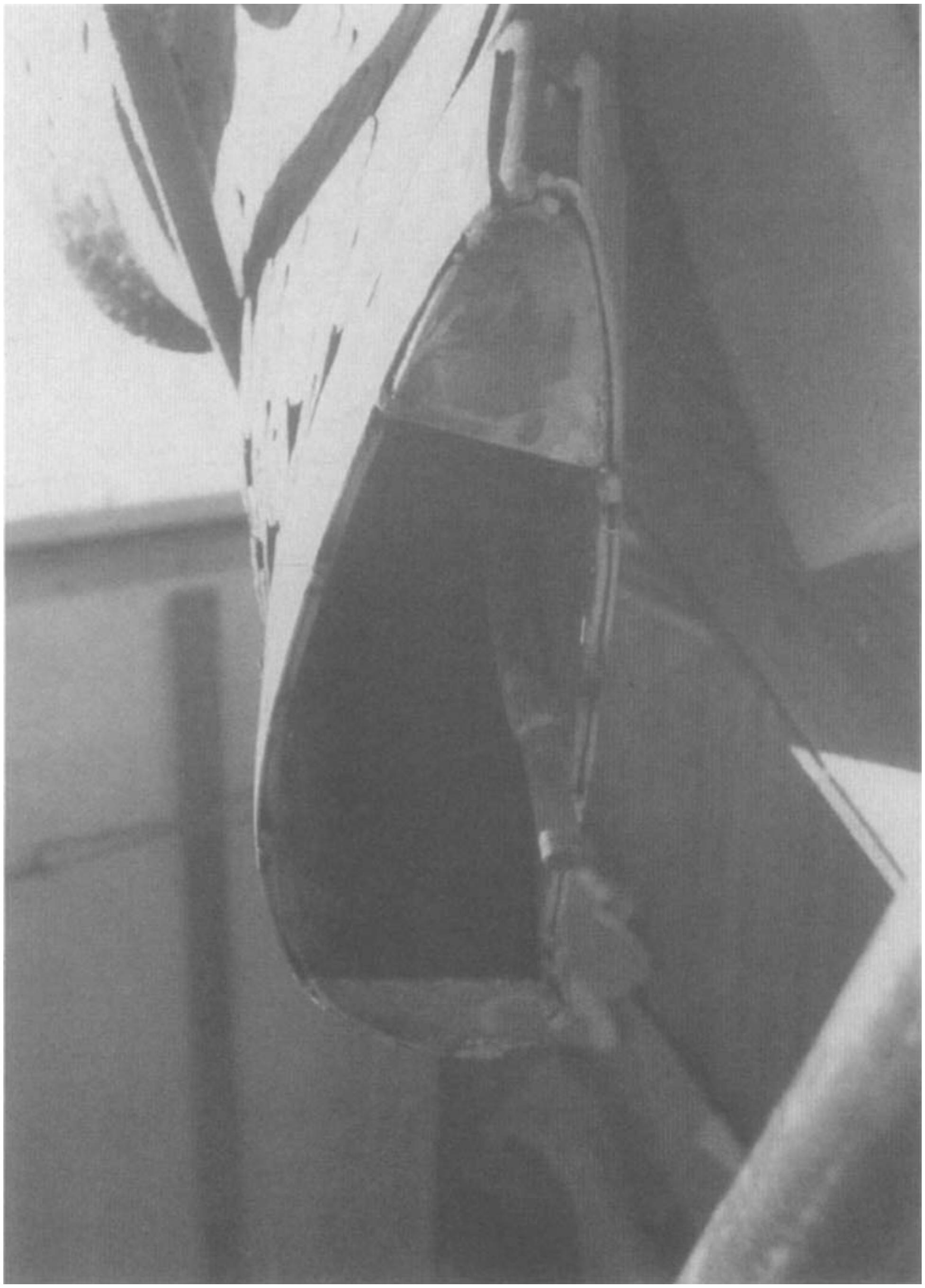

Figure 13. Detail of the body end of wing, showing the threaded end of the new armature. The photograph also shows bronze shims and partial end-plates, tack-welded in place, to achieve a snug fit of the wing in the body.

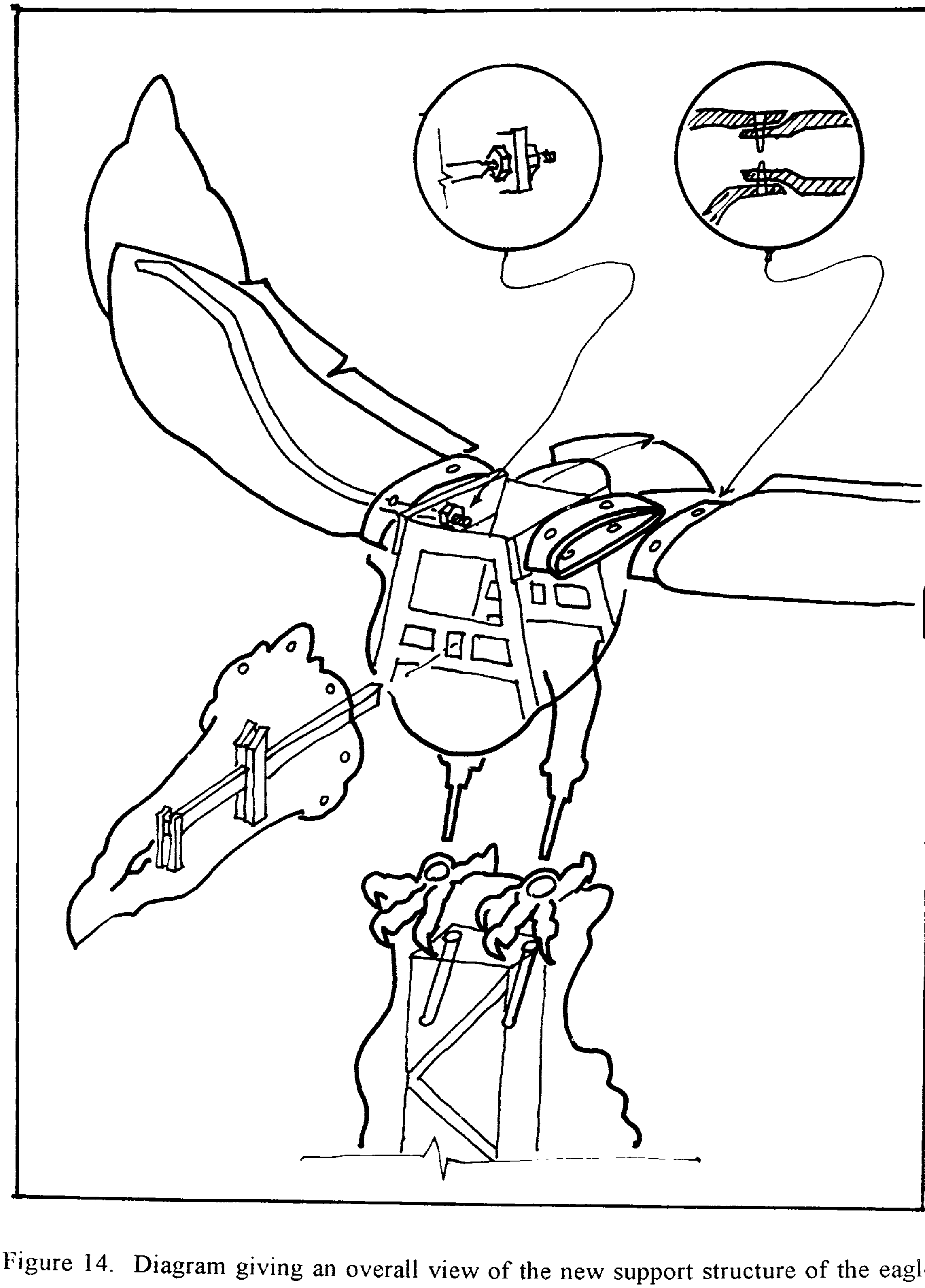

Figure 14. Diagram giving an overall view of the new support structure of the eagle.

Figure 15. General view, *in situ*, after treatment.

THE ANALYSIS AND RECONSTRUCTION OF ISLAMIC GLASS-FRIT CERAMICS, AND COMPARATIVE METHODS OF DESALINATION

Richard Barden

The Freer Collection

The Freer Gallery of Art has a collection of medieval Islamic glazed glass-frit ceramics, from Raqqa, Syria. Raqqa was a major medieval Islamic ceramics manufacturing city located in the northeast section of Syria. The collection at the Freer Gallery consists mostly of functional wares such as dishes, bottles, and storage containers. There are also a few figurines.

Ceramics with frit as a major component (usually about 20%) of the body are known as glass frit ceramics. Frit is made from a mixture of silica and potash, and/or soda ash, melted together to form a glass, which is ground into a powder.

Numerous pieces in this collection have deteriorating glazes and obvious salt problems. The question of how to treat ceramics with deteriorating glazes and salt problems, can be complicated. The standard, static water bath method of removing salts is effective, but can take several days to several months to be completed. Does this treatment cause a loss of material from a ceramic body or glaze? If there is a loss, is it significant? Is this treatment more detrimental to ceramics with deteriorating glazes?

Regardless of the answers to these questions, the best policy would be to use the least intrusive method with the shortest desalination time. The objective of my research was to reproduce this glass frit ceramic, and compare four methods of desalination. My goal was to determine the most efficient method, including how labor intensive and complicated the methods are.

The tests performed in this research were done with the practicality of treatments in mind. Although the samples were desalinated several times, which would not be true of an actual object, I performed the desalination procedures as I would treat a ceramic object in a museum environment.

Analysis of the Ceramic

Analysis of the Raqqa ceramics was done using ten samples taken from sherds in the Freer's Raqqa study collection, and five samples taken from sherds excavated at Rayy (another major site of medieval Islamic ceramic production) in the collection of the University of Pennsylvania Museum,. Analysis was performed using scanning electron microscope and microprobe.

SEM analysis was performed on five of the Freer samples. The elements were identified, and their percentages determined, in the glaze, the inter-particle glass, and the body.

Silica was identified as the largest component in each area of the ceramic, ranging from 71.5 to 77%. The elements that are the modifiers and fluxes make up 21.5 % in the glaze, 25% in the inter-particle glass, and 19% in the body.

Using SEM photographs it was possible to see the extent of vitrification, the integration of glaze and body, and the degree to which the components of the body were blended together.

SEM microprobe was used on all fifteen samples to determine which compounds, in what percentage, are present in the ceramic. Ninety-nine percent of the ceramic is made up of the oxides of silica, sodium, calcium and magnesium. The remainder is made up of the oxides of aluminum, iron and potassium.

A small unglazed sample from one of the Raqqa shards was crushed and sieved through various sized mesh screens. Each portion of the sample caught by the individual screens was then weighed. This gave a weight to size ratio. Approximately two thirds of the weight was in particle sizes under 420 microns, one third of the weight had particle sizes greater than 420 microns.

This analysis, in conjunction with the use of historical references and other modern analysis of Islamic ceramics, gave me the data I needed to reproduce this type of glass frit ceramic.

Reproduction of the Ceramic

The first step in the reproduction of the ceramic was to create a frit of similar chemical composition as the inter-particle glass. The frit was made from quartz, soda ash, potash, magnesium and calcium carbonates and pyrophyllite clay. These were melted together to form a glass. The molten glass was poured into cold water to shatter it, and then ground into a frit.

After the frit was produced, I mixed the materials for the ceramic body, which is composed of silica, frit, and clay. The silica was of various sizes to match the size to weight ratio of the Raqqa ceramic.

All the constituents for the body were mixed together dry, and water was then added. When the clay body was at an appropriate consistency it was wedged, rolled into 1/4 inch thick sheets and cut into tiles four inches long, and two inches wide.

After the tiles were dry, their tops were dipped into a glaze mix. A blue glaze was made by adding 0.8% copper oxide to the raw materials of the frit.

Historically these ceramics were fired around 1000° C. Various firing times and temperatures were tested using several tiles. After firing, the test tiles were broken open, and a microscopic comparison was made between the test tiles and the Raqqa shards. The tile that most resembled the Raqqa ceramic was chosen, and its firing time and temperature used to fire the rest of the tiles. The firing sequence chosen was the following: one hour at 200°C, one hour at 500°C, 20 minutes at 700°C, 20 minutes at 750°C, fifteen minutes at 800°C, and one hour at 1000°C.

In all 34 tiles were successfully fired. Each tile was given a number, 1 through 34, on its bottom. One tile was set aside as a control.

Analysis of the Salts and Choice of Salts for Testing

Salts from the desalination of a Raqqa jug (F 05.243) were reclaimed and analyzed to help select the salts to be used in the desalination tests. The problems of this object were typical of the collection, and I consider these salts representative of salts found in this ceramic collection. A sample of these salts was analyzed by SEM and X-ray diffraction.

The Raqqa jug contained a complex mixture of salts. X-ray diffraction was not able to identify a single, specific mineral to match the salts. However, several minerals came close to matching segments of this analysis, including sodium chloride, potassium sodium chloride, and sodium nitrate sulfate hydrate.

Potassium chloride was chosen as the salt to use in the desalination tests, as potassium and chloride were present in the Raqqa salts, it is commonly found in archaeological ceramics, it is readily soluble in water, and can be easily absorbed into, and removed from, the ceramic tiles.

Desalination Methods and Procedures

Salts were absorbed into the tiles through capillary action using a two molar potassium chloride solution. The tiles were placed on their short side in the salt solution. The solution covered approximately one inch of the tile, leaving most of the tile open to the atmosphere. To keep the salts evenly distributed in the solution, and to aid in their absorption, the bath was kept under constant mild agitation using magnetic stir-bars. The tiles were in each salt absorption bath for five days.

The tiles were infused with salts and desalinated three times. The average amount of salts impregnated into the tiles varied with each infusion. The average weight gain was 2.4 grams, about 3% of the average tile weight.

Each desalination bath contained 1.5 liters of distilled water. Conductivity was used to determine the end point of the desalination. Because of the relatively quick desalination times the end point chosen was a conductivity measurement below 50 micromohs after 24 hours of soaking.

After each absorption or desalination bath, the tiles were air dried for two days, oven dried at 100° C for one day, and left for three days to return to ambient temperature and relative humidity.

As a measure of the amount of salts absorbed into and removed from the tiles, the tiles were weighed before any tests were performed, after each salt infusion, and after each desalination test. The tiles were weighed dry, and to a 10,000th of a gram.

Four desalination methods were compared: (1) the standard method, (2) the bath changes method, (3) a circulating bath with bath changes, and (4) electrophoresis with bath changes.

The standard method consists of placing the tile on risers, and then immersing it in a distilled water bath. After 24 hours, the conductivity of the solution is measured, and the bath water changed. This continues until the treatment is complete.

The second method of desalination, "bath changes", uses the standard method, with the bath water changed between one and five times in the first eight hours. The baths were then changed every 24 hours until the treatment was completed.

The third method of desalination combined circulating water with bath changes. Using a peristaltic pump and plastic hose the water was circulated through the container six times per hour. The water entered at the top of the bath on one side, and was withdrawn from the bottom on the opposite side of the container. The bath water was changed after the first half hour, and then after every 24 hours.

The final method of desalination was electrophoresis with bath changes. Electrophoresis is the use of electronic fields to attract ions. This method speeds up the dissolution of the salts and increases their migration away from the ceramic. As the salts dissolve the ions are attracted to electronic fields of opposite charge, and repulsed by the fields with the same charge. The bath water was changed after the first half hour, and then after every 24 hours. Carbon electrodes were used, and a current of one tenth of an amp with enough voltage to complete the circuit. The electrophoresis ran for the entire time the tiles were immersed.

Results of desalination

Before any tests were performed, the first step was to immerse the recently fired tiles in static distilled water baths to insure that all soluble material was removed. This created a more uniform standard, and an equalized, beginning, conductivity level. The tiles were immersed for a total of thirteen days, until conductivity was below 100 micromohs for three consecutive days. Ending conductivity was 33 micromohs for the thirty-three tiles.

A total of 84 desalination tests were performed.

Of the tiles that were desalinated using the standard method, only seven percent were desalinated in 48 hours, seventy-three percent in 72 hours, and the remaining twenty percent took 96 hours. No other method took 96 hours to desalinate a tile.

For the bath changes method, sixty-four percent of the tiles were desalinated in 48 hours, the remaining thirty-six percent in 72 hours.

To break down the results of this method further, of the tiles with two baths in the first eight hours, sixty-four percent were desalinated in 48 hours, and thirty-six percent in 72 hours. After 5 bath changes, the desalination rate increases to seventy-three percent desalinated in 48 hours, and twenty-seven percent in 72 hours.

The circulating bath tests desalinated eighty-six percent of the tiles in 48 hours; the remaining fourteen percent took 72 hours.

The combination of electrophoresis and bath changes resulted in ninety-three percent of the tiles desalinated in 48 hours.

Conclusions

Compared to the standard method, all the other desalination methods were more efficient. The bath changes method is fifty-seven percent more efficient than the standard method. Even one bath change within the first eight hours greatly decreased the desalination time.

However, increasing the bath changes to five times in the first eight hours decreased the desalination time by only nine percent. This decrease is not significant enough to justify the added labor or the possible harmful consequences to the ceramic due to the added handling.

The circulating bath method was twenty-two percent more efficient than bath changes, and electrophoresis twenty-nine percent more efficient. However, both methods are more work-intensive, requiring more equipment, monitoring, and electricity.

The tubes for the circulating bath cracked several times from the action of the peristaltic pump. The water was then completely pumped out of the container and the tile dried. The possible damage to an object if the ceramic dries out before the salts are removed needs to be considered. The pump should be operated only during working hours, and the hoses examined periodically and replaced at the first sign of wear.

During electrophoresis, excessively high current caused the cathode to deteriorate, and particles from the electrode transferred to the tiles. Therefore the current must be set at proper levels and monitored.

Another question concerns the loss of ceramic material due to desalination, and its significance. In my tests the tiles weighed less after the desalination, but the average weight loss was 9/100 of a gram, approximately one tenth of one percent of the average tile weight. This loss occurred after repeated baths and oven drying which is not normally done.

Other questions have not yet been answered: Would the circulating bath remove more ceramic material than a static bath? When using electrophoresis, do the electric fields pull out soluble ions from the ceramic that would be unaffected by a static bath? I hope that further research will be performed to find the answers.

I would not hesitate to use the bath changes method. Changing the bath one time within the first eight hours will greatly decrease the desalination time, and this method will not harm the ceramic any more than the standard method. I would also use a circulating bath once the problem of the hoses had been solved.

Electrophoresis appears to be the most efficient method, though I have reservations regarding its use. I would like to find better electrodes, and feel more research should be performed before this method is widely used.

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DESALINATION PARAMETERS FOR HARAPPAN CERAMICS

Katherine A. Holbrow, Emily Kaplan and Harriet F. Beaubien

Abstract

In a pilot study to determine what soluble salt content would produce minimal damage in porous, low-fired archaeological ceramics, terra cotta bangle bracelet fragments excavated at the Indus Civilization site of Harappa, Pakistan, were desalinated to different controlled salt levels and subjected to various tests. Data from these tests were used to design a long-term study at the site. Preliminary results from the pilot study show that although some soluble salt remains after desalination treatment and in accelerated aging tests, no efflorescence or damage was evident in variously desalinated samples.

1. Introduction

Numerous terra cotta artifacts from the Indus Civilization, the earliest fully developed urban society in South Asia, are currently being excavated at the archaeological site of Harappa, Pakistan. The extremely high soluble salt content of the soil, excavated materials, and available water, in combination with severely limited resources, has fostered an ongoing research project intended to determine what soluble salt limits should be considered acceptable in desalination treatments.

The Indus Civilization encompassed a geographic area which included what is now Pakistan, Afghanistan, northwestern India, and parts of Iran and Central Asia. The archaeological site at Harappa includes a walled city which is laid out in a grid and built largely of mud brick and fired brick. Ceramic artifacts commonly found there include not only vessels but small figurines, toys, and ornaments, all displaying extraordinary standardization. Most excavated material from Harappa dates to the civilization's "mature" or flourishing period, roughly 2600-1900 BC.

Conservation at Harappa has been conducted through the Smithsonian Institution's Conservation Analytical Laboratory (CAL) since 1986. Under the auspices of the Archaeological Conservation Internship Program initiated in 1990, interns and fellows have worked at the site under the direction of Harriet F. Beaubien, treating copper alloys, gold, stone, ivory, bone, shell, and faience as well as terra cotta and other types of ceramics.

Research on desalination to date has focussed on evaluating damage to ceramics, identifying salts and their behavior, and designing efficient desalination treatments. Although desalination of ceramics is a conventional conservation treatment, determining a final or "acceptable" level of salt (i.e. salts allowed to remain in the ceramic), has been anecdotal or arbitrary. This is in part because "zero" conductivity, as measured in the final bath, has seemed both the safest option and an attainable goal under most conditions.

Harappa offers a somewhat different perspective on the problems of soluble salts and ceramics, because of a combination of extreme circumstances. Firstly, the salt content of excavated material at the site is extraordinarily high. Conductivity of waste water from the initial baths for ceramics invariably registers over 5000 µmohs/cm. Secondly, available water is very high in soluble salts. Measurements vary, but tap water from wells can have a conductivity of 3000 µmohs/cm, while riverine irrigation canal water can have a conductivity of 300-500 µmohs/cm. To desalinate ceramics below this level, water must be distilled. As at many archaeological sites in remote locations, power to run the stills is limited and expensive, as is access to equipment, parts, and supplies. Finally, the volume of excavated material is enormous: roughly 6000 batches of artifacts were processed through the conservation laboratory in 1994, and over 7000 were processed in 1995 (a batch may contain 30 or more items). Of these objects, about 50% are ceramic, all of which contain substantial amounts of soluble salts. Of these, a very large proportion are low-fired, terra cotta bangle bracelet fragments which are considered study pieces and are not accessioned.

In sum, desalination and processing of such a large quantity of artifacts puts a great strain on all available resources, which in turn can limit treatment of vulnerable accessioned objects. A substantial amount of time, labor, power, and water could be saved if the desalination of study items like bangle fragments were limited without compromising their stability.

2. Project Goals

The question which prompted the development of the research project is, therefore, whether some amount of soluble salt could be safely left in a terra cotta object such as a bangle bracelet fragment. This "safe" salt level (as measured by its terminal conductivity level) would not affect the stability of the ceramic under standard storage conditions at the site.

The project was conceived of in two parts: the research design and pilot tests, or "pilot study", and the "long-term study" now taking place at CAL and at Harappa. The pilot study was intended to test procedures; results from these would be used to refine the experimental design for the long-term study. The latter would provide a "real time" basis for evaluating the research question. Other CAL archaeological conservation internship program participants, including Marie Svoboda and Tania Collas, are involved in both the pilot and long-term studies, along with CAL objects conservation staff.

3. Pilot Study

In the pilot study, procedures in four areas of experimental design were considered and selected for the preparation of samples at Harappa, and for preliminary analysis at Harappa and CAL. These areas were sample selection and treatment, characterization of the samples, evaluation of change, and aging methods.

Sample selection and treatment

Two commonly found bangle types were used as samples: one small (approximately 1 cm) in diameter, and the other larger (1.5 to 2 cm in diameter). Five of each type of bangle were cut into six pieces, then pieces from each bangle were desalinated in groups to levels of 400, 300, 200, 100, and zero µmohs/cm. Remaining samples (one from each bangle) were left untreated, as controls. Two additional examples of the large type were also processed for destructive analysis. During desalination, the water-to-ceramic ratio used was 2:1 by weight, and salt levels were measured with a LaMotte conductivity meter. Conductivity levels of the final baths were maintained for 24 hours.

This range of salt levels was selected because of the significant implications for water usage. The higher end -- 400 µmohs/cm -- could be achieved at Harappa using a substantial amount of irrigation canal water and a minimal amount of distilled water or, conceivably, no distilled water at all. If desalination of bangle fragments could be terminated at this level, it was estimated that current distilled water use could be cut by approximately 90%, saving considerable time and energy. Even desalinating bangle fragments to 100 µmohs/cm rather than zero would result in substantial savings. In addition, each drop of water with a conductivity between 100 and 400 µmohs/cm could be re-used in the desalination process. The 100 µmohs/cm increments were chosen because they made the tests easier to execute and interpret.

Characterization of the samples

Because paste composition, porosity, and firing temperature can all affect the response of a ceramic to soluble salts, visual examination and several instrumental techniques were used to characterize the paste of the bangles. Variations in firing conditions were apparent from the presence of black cores in samples from one small and two large bangles.

Scanning electron microscopy (SEM), performed on the control and the "zero" samples from the two extra bangles, was used to assess porosity and variations in firing; the black-cored bangle appeared noticeably more vitreous. Energy dispersive x-ray spectrometry (EDS) showed elements typical of a ceramic including silicon, aluminum, oxygen, iron, and magnesium. CAL research chemist M. James Blackman, who has performed earlier analyses of Harappan ceramics (Blackman and Vidale, 1989), assisted in examining petrographic thin sections to better understand porosity, temper, and other inclusions. Thin sections were prepared from the "zero" samples of three small and three large bangle fragments. Examined under crossed polars, these showed a highly porous ceramic, with numerous calcitic inclusions and fold lines indicating manufacture by rolling.

Characterization of the salts found in Harappan ceramics has been carried out at CAL in previous years using efflorescent salt samples, examined with x-ray diffraction (XRD) by Harriet F. Beaubien (Beaubien, 1989-1993, unpublished). High proportions of sodium chloride and potassium chloride were found, as well as sodium sulfate and calcium sulfate. During the SEM/EDS examination of the bangle samples, sodium chloride was clearly identified. In a related research project using an unprocessed bangle and a sherd, salts were collected at CAL from sequential desalination baths. These are being analyzed to investigate the dissolution and diffusion trends of the constituent salt species; sodium and potassium chlorides and calcium sulfate were identified using XRD with EDS.

SEM/EDS provided important information and will continue to be used. During SEM examination of the ceramic structure of the bangle fragments, salt crystals in the matrix were observed before and after desalination and aging. A significant result of this examination was the recognition that salts were present in all samples examined, even those desalinated to a conductivity of "zero" µmohs/cm. Pockets of salt crystals, identified as sodium chloride using EDS, were visible throughout the "zero" sample.

Evaluating change

Weight measurements were selected as a method to measure loss of ceramic material through the action of salts, but it is not yet clear that changes will be detectable on the equipment available at the site. Scratch tests, stress tests, and indentation or puncture tests were considered as means to evaluate mechanical change. While scratch tests carried out on the "zero" samples generally distinguished the harder black-cored samples from the others, no consensus could be reached on the validity of scratch or indentation tests for damage evaluation purposes. Given the small size and irregular shape of the samples, meaningful results would be difficult to obtain with standard mechanical testing equipment and these tests were discarded.

Visual examination was selected as the primary method for evaluating the samples. At the site, a simple comparison of treated and control samples with the naked eye was performed by excavation participants. However, differences between samples desalinated to different salt levels were not apparent before aging. Examination with a binocular microscope at the site proved useful for fine distinctions between samples, and samples brought back to CAL will be further examined in this way. To assist in the evaluation of change over time, a system of degradation with the use of photographic standards is being developed.

Aging methods

Short term accelerated aging in a commercial cycling humidity and temperature chamber at CAL was attempted, but the chamber proved difficult to control, and no changes were noted in the control and "zero" samples from the two extra bangles. More successful was cycling in chambers regulated by desiccated silica gel and containers of water. In an ongoing experiment at CAL, the small bangle samples were cycled between 10% and 90% RH at one week intervals, for six months, at ambient temperature. Preliminary results show that only the control samples (i.e., those not desalinated) exhibit any visible efflorescence or damage. All samples desalinated to 400 µmhos/cm or lower appeared unchanged.

4. Long-term Study

The long-term study began in the spring of 1995 and is now underway at Harappa and at CAL. The results of the pilot study were used to support this longer study and suggested modifications in the experimental design.

Sample selection

To reduce variables introduced by differences in bangle types and firing history, the sample pool for the long-term study was narrowed to the small bangle type only. The number of samples was increased to 60 bangles of a uniform appearance and size, cut into 378 samples, to allow for periodic destructive analysis. Groups of samples were treated by desalination to different controlled conductivity levels, again requiring maintenance at the final level for 24 hours. Conductivity of the different groups measured zero, 100, 200, 300, and 400 µmhos/cm; undesalinated controls are estimated to have a conductivity of greater than 5000 µmhos/cm.

Characterization of the samples

Characterization of both the ceramic and the salts will continue at CAL. Eighteen sample pieces will be sent to Blackman for neutron activation analysis of the paste and for thin section petrography. Continuation of systematic analysis of soluble salts and their diffusion rates is planned at CAL, using evaporates from sequential desalination baths of the bangle samples processed for the long-term study.

Evaluation of change

The samples will be examined periodically for changes in visible salt efflorescence, surface and structural change, and changes in weight. Visual changes will be quantified by comparing samples to photographs of a series in increasingly degraded condition. Analysis using SEM will continue on selected samples as they age, both for characterization and for indications of microstructural damage.

Aging methods

For the long-term study, real-time aging of the treated samples is taking place under real storage conditions at Harappa. Like most buildings at the site, the ceramics storeroom at Harappa is brick, which serves to insulate it somewhat. However, Pakistan's temperature and relative humidity fluctuations are extreme, and salts are likely to deliquesce many times during a year. The samples will be examined annually at Harappa, over five to ten years, with selected samples periodically brought back to CAL for analysis. Accelerated aging tests are planned at CAL to support possible expansion of the study's selected desalination levels.

5. Conclusions

While the long-term project is in its earliest stages, the pilot study provided many useful indicators for experimental design as well as some interesting conclusions. The presence of salt crystals in all samples, including the one desalinated to the lowest detectable conductivity limits, suggests that desalination treatments are not as effective as may have been thought. The fact that preliminary aging tests produced damage over time only in the "control" (i.e. undesalinated) samples, while all others remained in stable condition, suggests that leaving some salt in these ceramics may well be a safe conservation option. Determining how much salt can safely remain, and under what environmental conditions, will require further research.

The absence of damage and efflorescent crystal growth in the aged, partly-desalinated samples needs to be considered in another light as well. Situations arising in the field can be difficult or impossible to replicate in the laboratory; the conditions, durations, and results of accelerated aging cannot be correlated specifically with real conditions. Although damage was evident in the laboratory-aged undesalinated samples, they did not show salt growth comparable to that seen at Harappa despite their high salt content. The largest salt crystals obtained in the laboratory were minuscule in volume compared to salts found at the site. Similar failures have been reported anecdotally by other conservators. The pilot study prompted a prioritization of goals, and it was resolved that the central focus of the project was *not* to mimic soluble salt growth in the laboratory, but to determine practical desalination limits in a specific situation. This resolution underlies the decision to use real-time aging on the samples in storage at Harappa.

A real-time aging study is rewarding and possible in this case, where the value of obtaining useful results outweighs the disadvantage of the time needed to get these results. The Harappa excavation offers a unique research opportunity including the extreme nature of the salt problems, and the availability of sample material for use in tests. More importantly, Harappa is an established, ongoing excavation and closely affiliated to the conservation research community at CAL. Such fortunate circumstances make a five- to ten-year study possible.

Acknowledgements

We offer sincere thanks to everyone who participated in this project, especially to Carol Grissom, head of objects conservation at the Smithsonian Institution's Conservation Analytical Laboratory; to Drs. Richard Meadow, J. Mark Kenoyer, and Rita Wright, directors of the Harappa Archaeological Research Project; and to the Samuel H. Kress Foundation. The generous support and encouragement of all made this project possible.

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Reference

Blackman, M. James, and Massimo Vidale. 1989. The Production and Distribution of Stoneware Bangles at Mohenjo-Daro and Harappa as Monitored by Chemical Characterization Studies. In *South Asian Archaeology 1989*. Madison, WI: Prehistory Press. 37-43.

THE EFFECTS OF DESALINATION ON ARCHAEOLOGICAL CERAMICS WITH EVIDENCE OF USE

Jo Wiley

Abstract

A preliminary investigation into the effects of desalination on archaeological ceramics from the Casas Grandes region in northern Mexico, with evidence of use as cooking pots, was carried out. Soluble salts extracted during desalination were identified by ion chromatography (IC) and inductively coupled emission spectroscopy (ICP). The results were related to local raw materials and the burial environment in the Casas Grandes region.

The extraction of other soluble components in the ceramics during desalination, such as organic materials used in the manufacture or present as a result of use, was investigated by analyzing dry residues of the desalination solutions. Fourier transform infra-red spectroscopsy (FTIR), pyrolysis gas chromatography (Py-GC) and X-ray diffraction (XRD) were used to analyze the desalination residues.

Changes in the microstructure as a result of prolonged immersion in distilled water were examined by petrographic analysis and scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM/EDS) of thin sections prepared from sherds before and after desalination. The effect of desalination on the physical property of color was also examined.

The results of the experimental work suggest that desalination has significant limitations that need to be considered before its application as a conservation treatment for archaeological and ethnographic ceramics with deterioration due to salts.

The results of this research project have been published as "The Effects of Desalination on Archaeological Ceramics from the Casas Grandes Region in Northern Mexico", in the Proceedings of the Fourth Symposium on Materials Issues in Art and Archaeology, Cancun 1994 (Materials Research Society, Volume 352, 1995).

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NON-ADHESIVE FILLS FOR WOOD

Tamsen Fuller

1. Introduction

This paper discusses non-adhesive fills for objects made of wood. Recently I have had the opportunity to treat a series of wood objects which have developed splits and other distortions. Most of the artifacts are of recent origin, and there was no history of the way in which the splitting would behave over time.

I was reluctant to create inappropriately rigid fills for wood pieces which might be still active, and I was equally reluctant to end with a failed system based on adhesives and fillers which could be difficult and possibly damaging to undo. I am also frequently reluctant to spend a lot of time on any one problem because, frankly, life is too short and the objects too many. These foam fills take minutes of concentrated time, compared to repeated intervals of time spent waiting for solvents to evaporate, smoothing adhesive-filler materials, and inpainting.

My work over the past few years has included many preventative conservation projects, i.e. packaging systems for storage and transit. These have given me experience with polyethylene and polypropylene in many forms and the ways in which these may be fabricated to meet specific needs. I commonly use foams, fluted sheets, films, tubing, and rods, and also frequently use these materials to make supports for objects during treatment. In storage, the usual white or translucent color of these materials is desirable for reasons of light reflectance, pest control, and generally sterile appearance.

Many of the physical attributes of the foams and other materials make them as attractive for use in treatments as they are in packaging solutions--reasonable cost, ease of fabrication, flexibility, and light weight. The problem with these materials in interventive treatments is that they are difficult to surface attractively because most of our adhesives, resins and paints will not adhere to the surface of polyethylene and polypropylene. It is clear, however, that if these foams could be made cosmetically acceptable, they could be valuable additions to our treatment arsenal for splitting and distorting wood.

Another problem is the lack of durability of foam fills which are soft and held in place only by friction fit. However, these same qualities made these fills harmless and totally reversible. During the course of the following treatments, I began to question the notion that I have held in the past that fills must be hard, color durable over the next 100 years, and resistant to damage from handling, washing, etc. Does it in fact matter so much if these mechanical fills fall out or become abraded as long as they can be easily and quickly redone with no damage to the object?

2. Case Histories

Kenyan medicine man self portrait

This contemporary portrait sculpture was purchased in Kenya and brought immediately to the Eastern United States. The arm was broken in transit, and there were radial splits in the side of the face and the front of the base. Within minutes the splits were filled with pieces of white 2 inch plank Ethafoam (polyethylene foam) and surfaced with 1/4 inch black Volara (polyethylene foam) adhered with hot melt adhesive. A soldering iron quickly produced a texture on the surface of the Volara.

Tau Tau figure

The same owner had collected this figure from Sulawesi. It had also developed a radial split in the face but was a lighter surface color which could not be mimicked by available foams.

The splits were filled with Volara 2A white polyethylene foam. The surface was colored with Liquitex acrylics and dry pigments worked over and into the surface with brushes and a heated soldering iron. Because the figure remains on the owner's darkened stairwell and is not touched, this was a successful treatment.

Tau Tau rack

By coincidence, the next treatment was another Tau Tau artifact, a miniature rack with figures. The rack was the problem, coming apart as the fresh wood distorted and its bark came off (Figs. 1, 2).

The gaps between the back slats and the frame were filled and the upcurved slats supported with pieces of Ethafoam polyethylene foam. Pressure was brought to bear with pieces of Coroplast (corrugated polypropylene sheet) held in place with pointed lengths of polypropylene welding rod (Figs. 3, 4). The ends of the rod were heated to curl the end so that it protruded less and put more pressure on the Coroplast washer (Fig. 5).

Thickened Rhoplex N580 acrylic emulsion was used to adhere pre-tinted Japanese tissue over the white foam where it showed through to the front of the rack (Fig. 6). Used as a contact adhesive, that is, applied to both substrates and allowed to dry before joining, this adhesive was a successful bonding agent.

The system is visible from the side and top, but the object is not viewed from these directions while on display in the owner's home (Fig. 7). From the front, the white materials are camouflaged, and with the Tau Tau figures in place, the owners were pleased.

Cameroon table

This table from the Cameroons is carved from a single tree trunk and has a round slab top, carved cats as the legs, and an open circle as the base. The top and the base have many radial splits. The splits in the top were filled with black Volara and wax was used as a surfacing agent. A heated soldering iron was used to slightly melt the polyethylene foam and the wax together. Since this treatment, I have used dry pigments alone, first brushed over the surface or picked up on the heated iron tip, to tone the foam, again heating and melting the surface of the foam to incorporate the pigment.

Stabilizing the bottom splits was a different type of problem, as the splits were both completely separated as well as quite narrow, some only .2 cm. wide. In addition, the interior of the splits was often splintery, and the lack of tensile strength in the Volara polyethylene foam made it impossible to draw a piece of foam through the entire split. It was found that two pieces of 4 mil polyethylene sheeting could be drawn through the splits, however.

It then proved possible to roll out a sheet of Pliacre epoxy putty, place it between two larger sheets of polyethylene film, insert the film through the split, and begin pulling the pliable epoxy through the split. Once the putty/film sandwich filled the split, it was left for the epoxy to cure. The excess epoxy was broken away and finished with mechanical means, and the excess polyethylene film cut with scissors or blade. A heated spatula was used to produce complete retraction of the excess polyethylene film into the split in the wood. The epoxy was inpainted with acrylic emulsion paints.

The polyethylene film cushions the fill system, so that the rigid epoxy does not cause problems if the wood should move in response to RH changes. The system is mechanically reversible, because one split is considerably wider than the others and relatively straight sided. The fill in that split can be pulled out, allowing movement in the rest of the splits so that they can be widened and their own fills pulled out.

3. Conclusion

Polyethylene foams offer an alternative means of filling splits in wood objects. The foam fills are easy to shape, can be surfaced with heat, wax, dry pigments or acrylic paints, and require very little expenditure of time or money. Combinations of materials, such as Ethafoam and Coroplast, or polyethylene sheet and epoxy putty, may solve problems where a single material will not be adequate.

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Sources of Materials

Polypropylene welding rod:
United States Plastics Corp.
1390 Neubrecht Road
Lima, Ohio 45801
1-800-537-9724

Coroplast polypropylene sheet:
Coroplast, Inc.
4501 Spring Valley Road
Dallas, Texas 75244
214-392-2241
1-800-666-2241
Fax 214-392-2242

Rhoplex N580 adhesive:
Conservation Materials, Ltd..
1395 Greg St., Suite 110
P.O. Box 2884
Sparks, Nevada 89431
702-331-0582
1-800-733-5283
Fax 702-331-0588

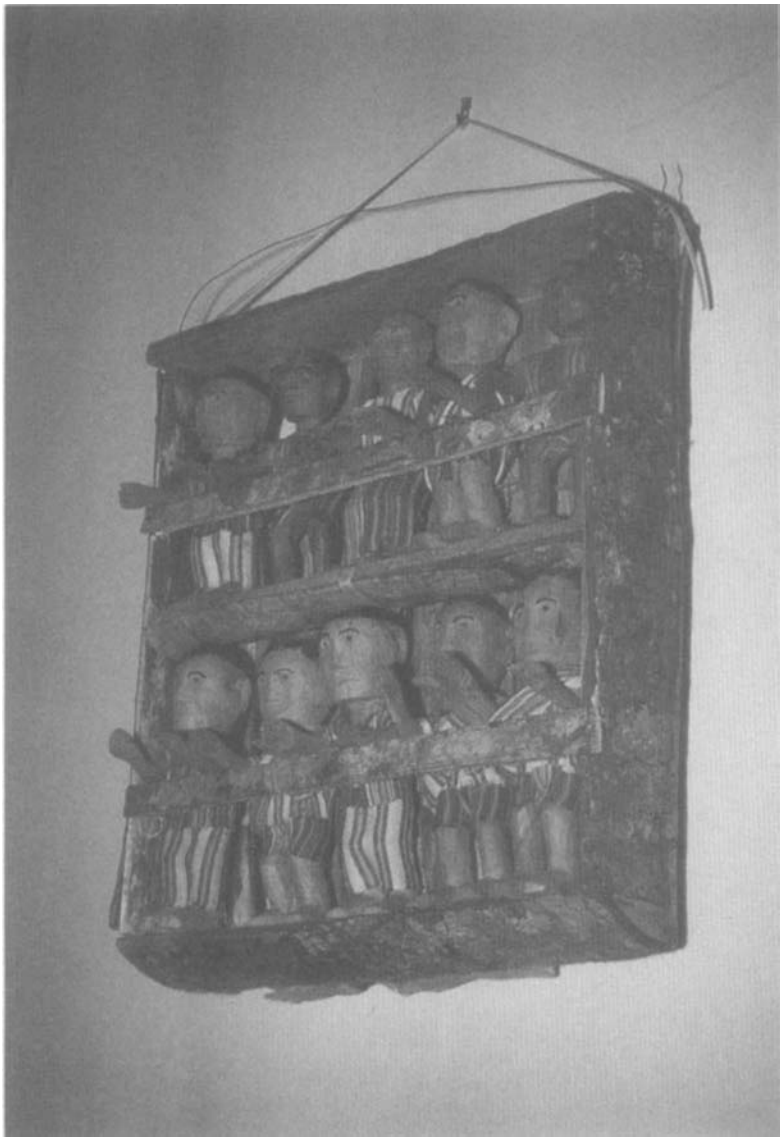

Figure 1. The Tau Tau rack and figures after treatment.

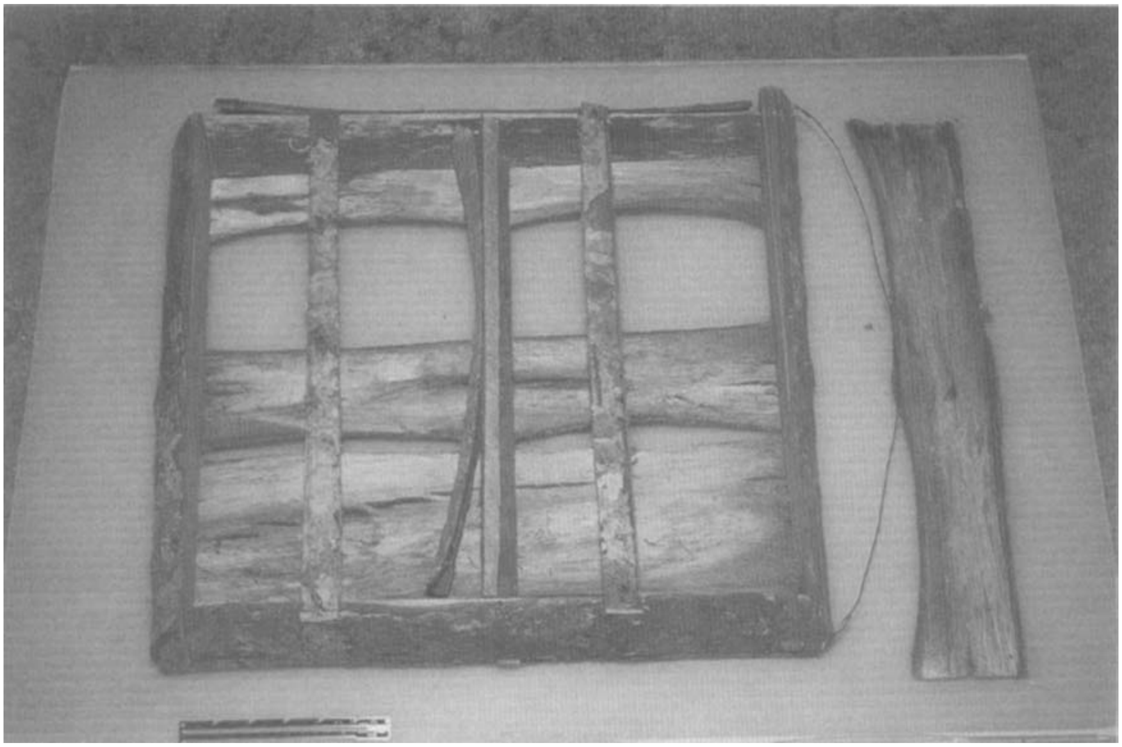

Figure 2. The rack before treatment, showing the warped back.

Figure 3. Clamping or pressure system with polypropylene rod pins and Coroplast.

Figure 4. Same as Fig. 3, with the Ethafoam block wedges supporting the bark and completing the system.

Figure 5. The polypropylene rod pin is heated locally and curled to make a head.

Figure 6. The rack showing tinted paper adhered to Ethafoam blocks with Rhoplex N580.

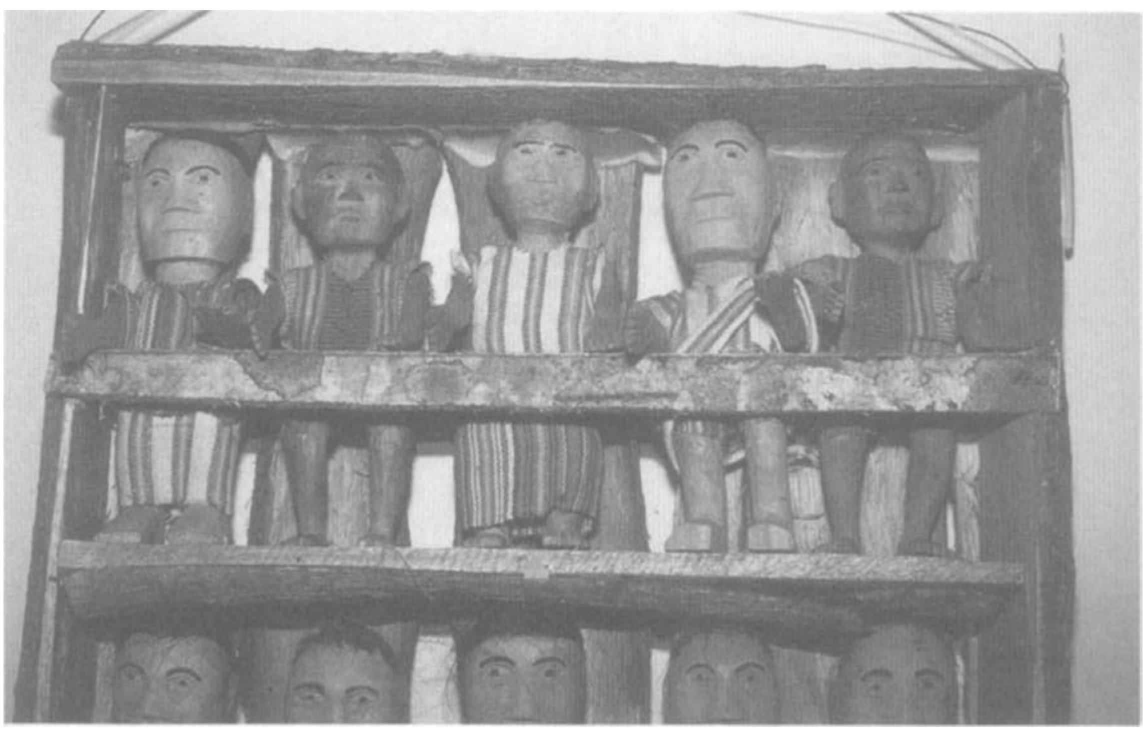

Figure 7. The figures installed, making the rack mends less noticeable.

COMPENSATING FOR LOSSES IN DESIGN WITH DECALS

Gregory S. Byrne

Ceramics have been decorated by transferring an image to the surface of the ware for more than two hundred years. In the process known as transfer printing, an image is captured from an engraved copper plate onto a sheet of paper and then pressed onto the unglazed surface of the ceramic. After the color is fixed, the paper is peeled away and the piece fired. Pieces decorated in this fashion became known as transferware. The transfer of multiple colors, decalcomania, was introduced about 1860. In this method the full color design is printed on paper and transferred to the glazed ceramic surface. Transfer printing and decalcomania, now called decals, were very popular in the mid-nineteenth century and often featured historic figures, scenes, and events. Today, the method of transferring an image to the surface of a ceramic includes photographically generated decals. Photo imaging techniques are also being used in furniture conservation treatment to compensate for losses in design and fabric (Sheetz 1984).

The decal technique presented here is derived from the popular decoupage craft revival of the late 1960s and early 1970s. One craft technique removes an image from its paper support by applying an emulsion coating over the image and transferring it to another surface. Once dry, the coated image is placed in water to soften and swell the paper. The image can then be transferred to another surface. This simple method of creating a decal has been adapted to use conservation materials with color laser imaging techniques to replicate lost designs.

In 1985, our conservation labs received dozens of decorative arts objects and historic furnishings from the Augustus St. Gaudens National Historic Site in Cornish, New Hampshire, which preserves the artistic legacy of this noted sculptor. Some artifacts were severely damaged, with major portions missing. This was the case with an Imari porcelain in the form of a stylized coy or carp, a good candidate for the development of a new treatment technique (Figure 1).

A photographically generated decal begins with a photocopy produced with a color laser copier. A Canon Color Laser Copier, the CCLC 500(CCLC) is used to produce a print from a 1:1 ratio, 4"x 5" color photo transparency. The CCLC can also produce a usable image from a 35 mm slide or photographic print if the quality and resolution are acceptable. One advantage of using the CCLC is that the color and size of the image can be adjusted to meet the requirements of a particular application (Figure 2).

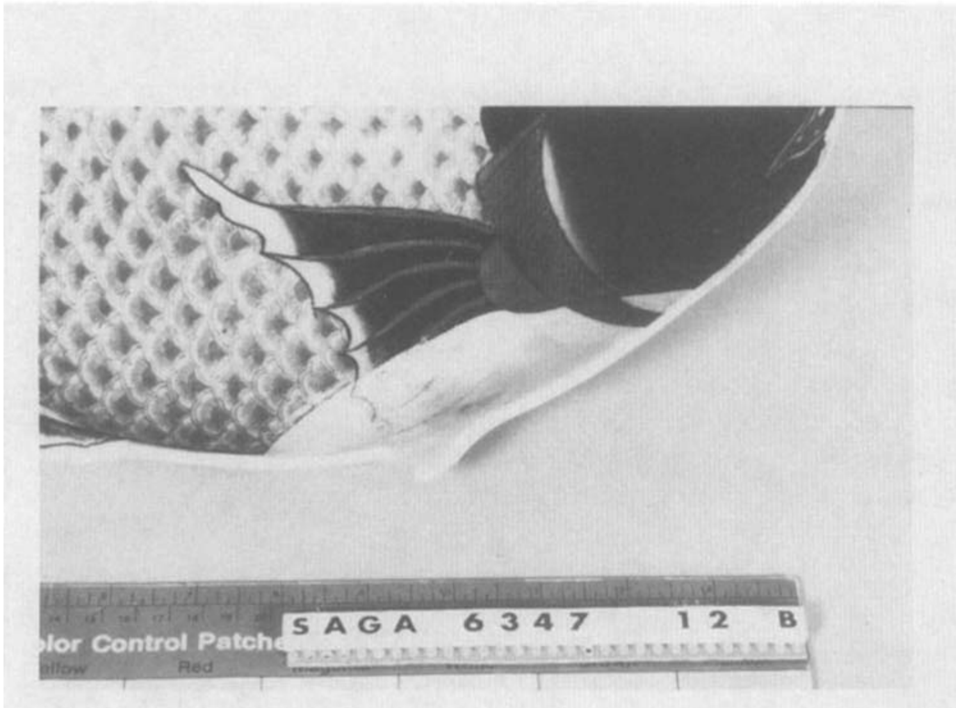

Figure 1: Imari porcelain selected for developmental treatment.

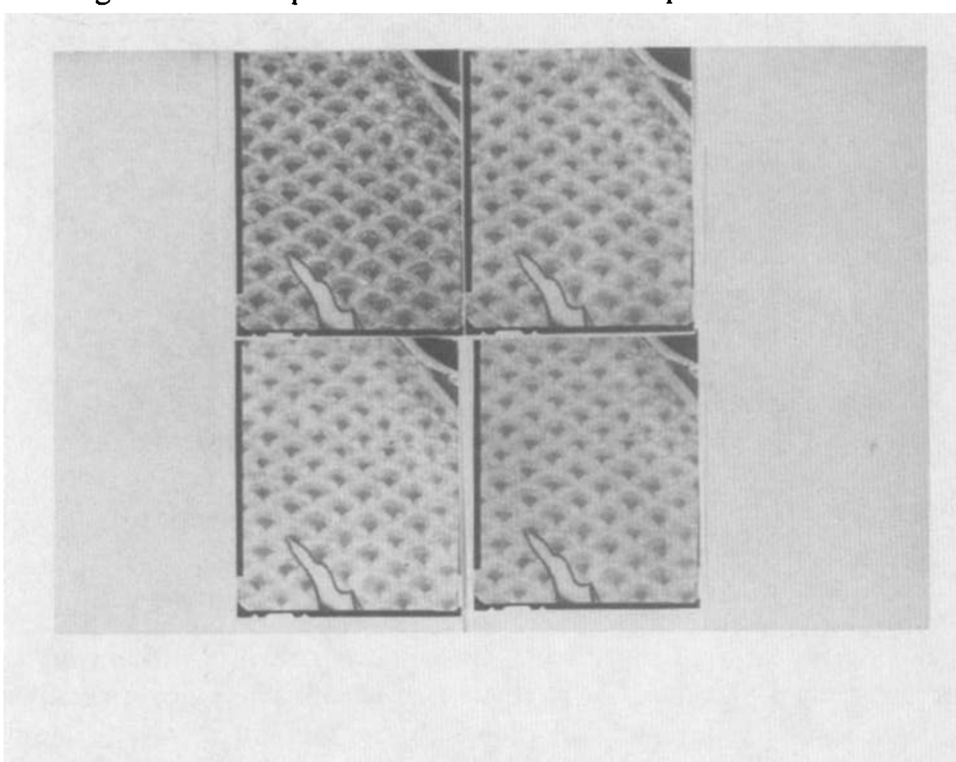

Figure 2: The color, size, and content of images can be digitally manipulated.

The CCLC's computer system can scan an image digitally, allowing the user to manipulate the content of the image. Once an acceptable laser image is printed, it is secured to a section of corrugated blueboard in preparation for the application of the coating transfer medium. The image is given a brief, mist-like spray coating of a dilute solution of water-borne urethane using a Devilbiss, Type FBA, Series 502, spray gun. In this case, 50 ml of Polyglaze, a water-borne polyurethane, is diluted by the addition of 50 ml of deionized water. A few drops of M-Pyrol (N-Methyl-2-pyrolidone) are added to aid leveling and flow. The air pressure for the spray gun is set at approximately 15-20 psi. If the first spray application of medium is more than a light mist coating, the paper becomes saturated and bonded to the dyes and dye binder, which makes it impossible to separate the two. Once dry, the process is repeated and again allowed to dry. Spray coatings are repeatedly applied until a readily visible, clear, uniform coating forms upon the surface (Figures 3, 4).

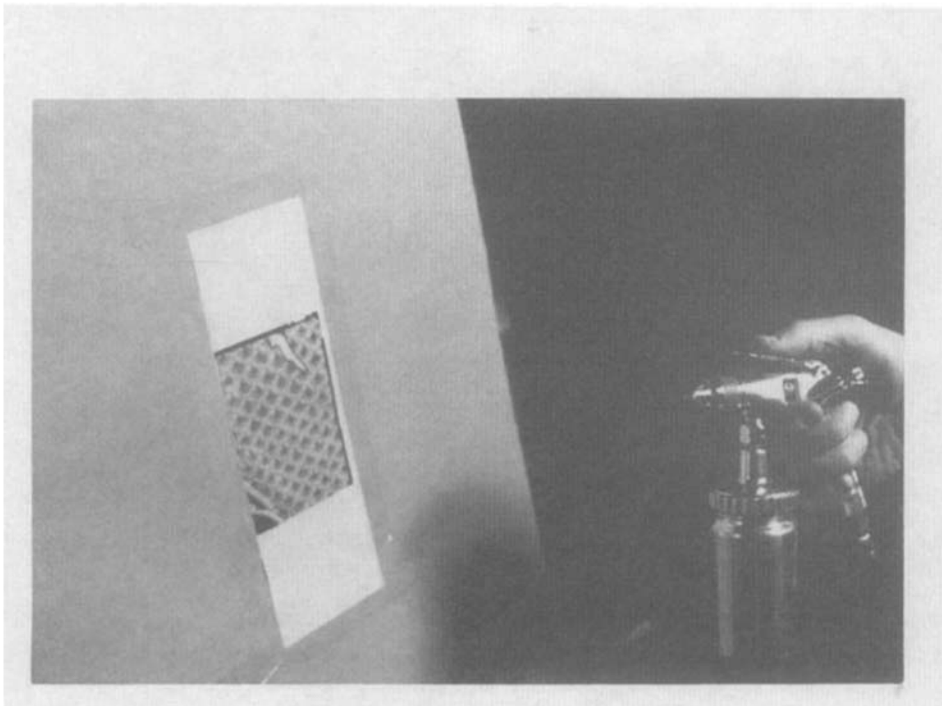

Figure 3: A mist coating is applied to the image.

Actual practice reveals that evaluating results are more important than following a prescribed three, four, or five spray application. Spray equipment manufacturers also generally recommend that repeated light spray applications will generate more satisfactory results and avoid drips, puddling, solvent and dust entrapment, and other problems that plague air brush and spray gun-applied finishes.

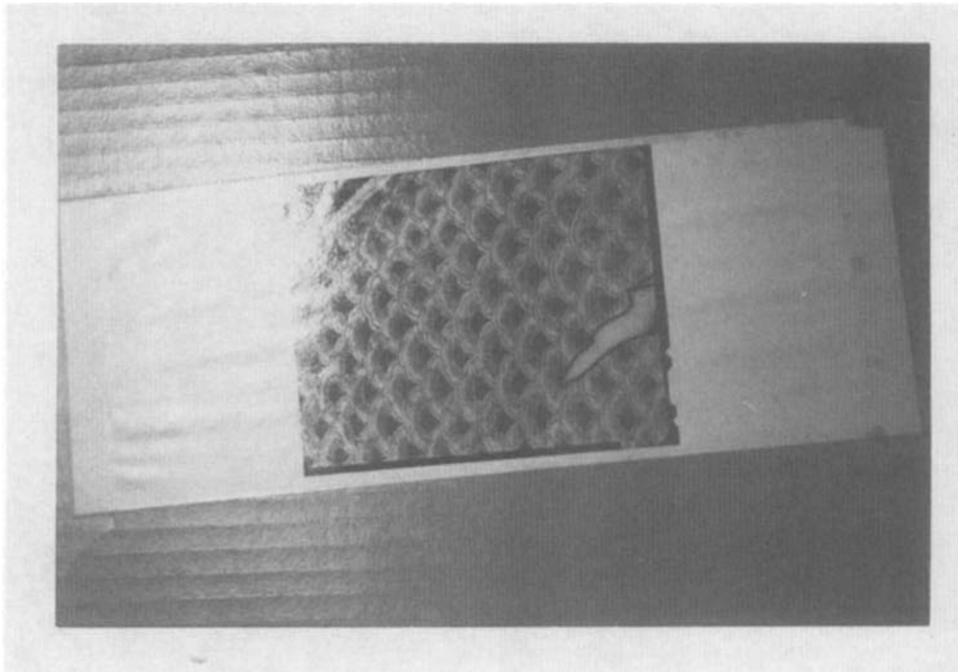

Figure 4: Coatings are applied until a uniform coating is achieved.

The dry coated image is then released from its support with a scalpel and placed in water for twenty minutes (Figure 5).

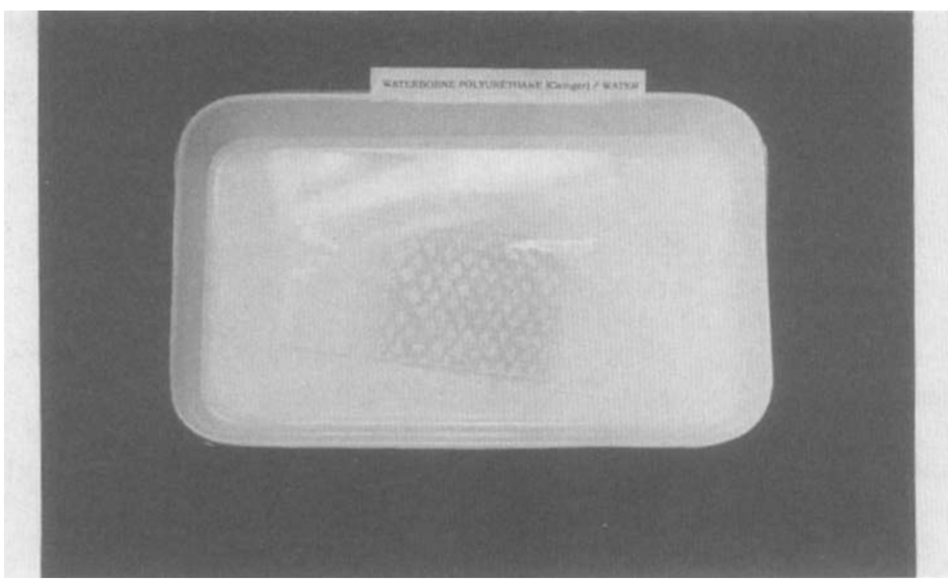

Figure 5: Immersion in water swells the paper fibers.

Wetting the paper swells the fibers, diminishing its cohesive strength. The paper is removed from the image by lightly rubbing away the cellulose fibers (Figure 6). Through trial and error, it was discovered that the paper was most easily removed from the image if it was placed face down upon a resilient cushioned surface of ¼" Volara polyethylene foam, to which a 3 mil polyethylene sheet was attached with double sided tape.

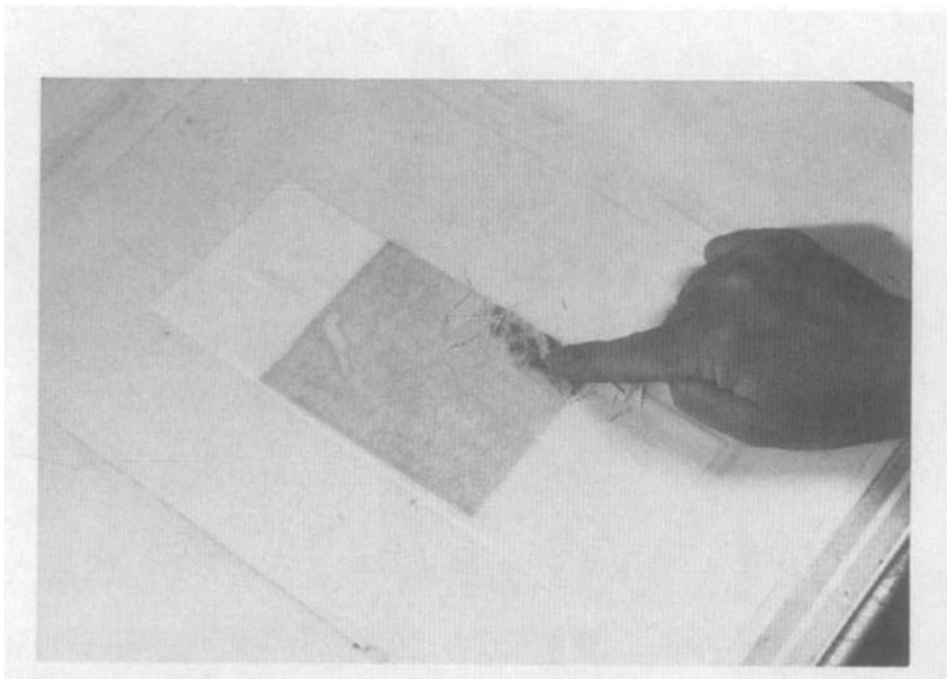

Figure 6: The swelled and softened paper is removed from the image.

Once the paper is removed, all that remains is the decal image contained in the transparent medium. The decal is then positioned over the fill or area of loss and taped on one side so it can be flipped back and forth (Figure 7). This allows for final surface preparation of the glazed porcelain. A final coating of Hxtal NYL-1 epoxy serves as the mordant to secure the decal. Once it is at full tack, or almost dry, the decal is repositioned upon the epoxy and left to complete its cure. The decal is finished by trimming with a scalpel and solvents and applying additional coats of epoxy to approximate a porcelain glaze (Figure 8).

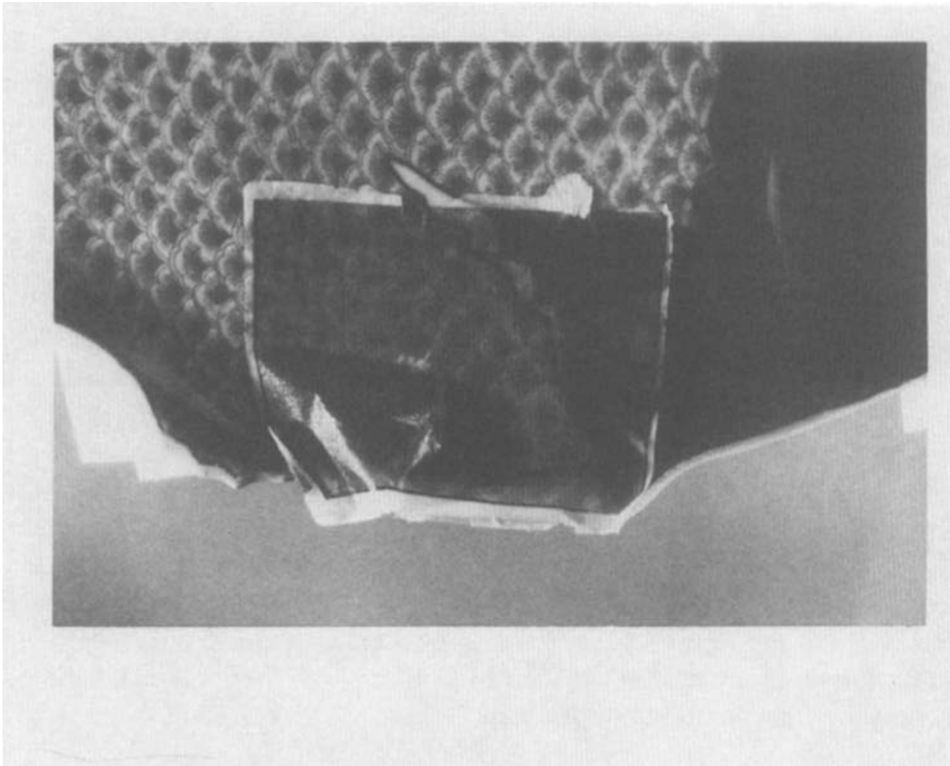

Figure 7: The untrimmed decal is positioned in place.

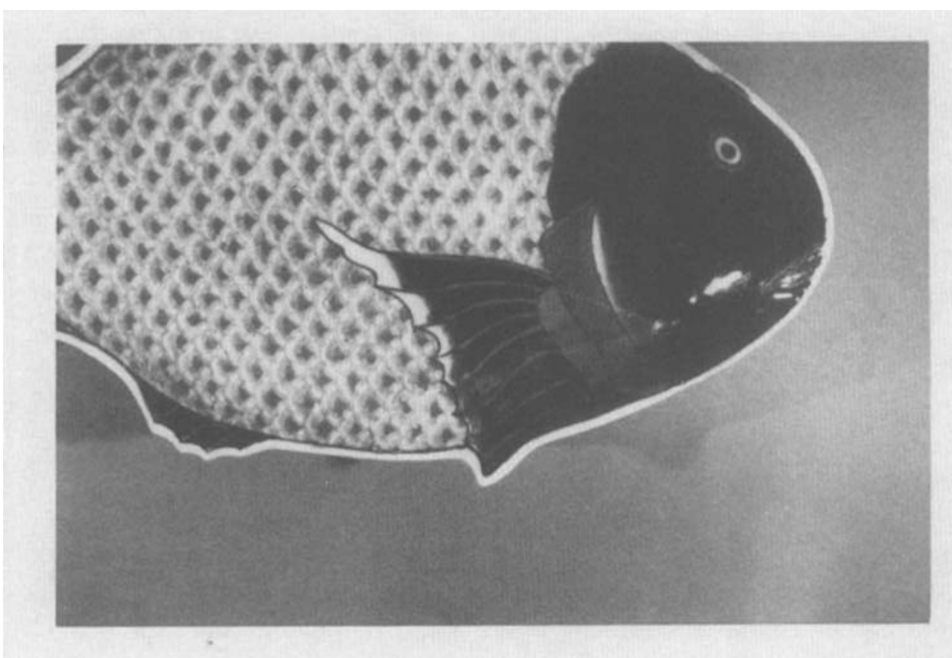

Figure 8: The positioned decal is finished by additional coatings.

The purpose of this exercise was to develop a process by which a decal could be generated. More recently, resins more familiar to conservation treatment have been employed. Experiments using Acryloid B-72 and B-48N solvent acrylics have also successfully produced decals with a modified technique. The CCLC image has a thermoplastic binder that is quite sensitive to non-polar solvents, making it difficult to apply a coating solvent in anything other than water, ethanol, or mixtures of the two. A dilute (sprayable) solution of B-72 in acetone can be sprayed over a CCLC image if the brief spray application is immediately followed by heat. A TORCHLAMP, held approximately 30 cm from the image surface, quickly drives off the solvent before it disturbs the image. As previously described, the process is repeated until a uniform coating is achieved. The difficulty encountered with this technique is that there is an inherent fire risk involved when using a TORCHLAMP with volatile, highly flammable, and potentially explosive materials. It should not be tried in anything other than a self-contained, industrial spray booth capable of moving large quantities of air per minute.

Epoxy systems are attractive candidates for use as a medium in creating decals. However, Hxtal NYL-1, and Epotek 301-1, both optical grade epoxies, did not produce satisfactory results. These epoxy systems tended to saturate both the image and the paper and bead up upon the image surface rather than form a uniform coating

Color stability and the long term aging characteristics are critical factors to consider in the selection of conservation materials and were unknowns in this experimental technique. Little information was available about the fading characteristics of the dyes used in the Canon system and prompted the following rudimentary test to evaluate color permanence. A CCLC image was placed in a south facing window for six months with half the image screened from light exposure. The print was exposed to approximately 7000 foot candles a day for six months. Although the color shifted, the stability of the print was impressive. The print was not periodically evaluated, so no information was gained about the rate of fading compared with the duration of light exposure. Subsequent to this work, and based upon light exposures in accelerated tests at 21.5 lux (2000 fc) 75°F (24°C) and 60% RH, CCLC printer color prints protected by a UF-3 ultraviolet filter will last about 40 years (H. Wilhelm 1993). The completed fish platter is exhibited at 5 fc in a UF-3 vitrine that will significantly increase its useful life.

Many recent developments, which include the availability of high-resolution film scanners, increasingly powerful and affordable desktop computers, high capacity data storage, sophisticated software, and high resolution ink jet printers with corresponding improvements in printer inks, all combine to challenge the traditional ways we think about photographic documentation and compensation techniques. The method and means by which compensation for loss on many types of objects, especially art on paper, could change dramatically in the next few years. Conceivably a conservator, curator, and art historian could gather round a high resolution monitor and make inpainting and compensation decisions while viewing the screen.

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A TRANSLUCENT WAX-RESIN FILL MATERIAL FOR THE COMPENSATION OF LOSSES IN OBJECTS

Susanne Gänsicke and John W. Hirx

Abstract

A thermoplastic synthetic wax-resin[1] mixture was developed by John W. Burke and Steve Colton for compensating losses to objects made from translucent materials. Polyvinyl Acetate PVA AYAC, Ethylene acrylic acid copolymers A-C 540 & 580, antioxidants Irganox 1076 or 1035, and a variety of possible fillers are melted together, applied to areas of loss, and sculpted to shape. This material is an aesthetically pleasing and reversible alternative to other compensation materials such as epoxy and polyester resins, or waxes.

Introduction

The compensation of losses in objects made from translucent materials such as alabaster, marble, calcite, diorite, and anhydrite has always been challenging. Traditionally, waxes, polyester, epoxy and acrylic resins bulked with a variety of materials and coloring agents to imitate stone have been applied to areas of loss, but to date no satisfactory solution has been found. Waxes tend to collect dust and dirt. Both polyester resins and epoxies are toxic and noxious. If applied directly to the area of loss, they can migrate into and catalyze within the stone. With time, both materials will yellow and can lead to internal staining. These resins are difficult to remove; they only swell in solvents rather than dissolving, which can cause cracking and delamination of the object. The application of low viscosity synthetic resins sometimes requires the creation of complicated molds. If multicolored or banded fills are required the work becomes even more complicated.

About ten years ago John Burke, Oakland Museum of California, and Steve Colton, Los Angeles County Museum of Art (LACMA), experimented with thermoplastic fill materials to compensate losses in alabaster objects. The formula of the wax-resin presented here was the outcome of their work and has been used by conservators in several museums since.[2] This paper attempts to compile the available information about the wax-resin components and provides further discussion on its applications and limitations. The mixture consists of Polyvinyl Acetate AYAC,[3] Ethylene acrylic acid copolymers A-C 540 & 580,[4] Irganox 1076 or 1035,[5] dry pigments, marble powder and other additives, which are melted together (Figure 1).

Components and Properties of the Fill Material

Polyvinyl Acetate resins are used variously by conservators from adhesives to varnishes (Horie 1987). PVA AYAC is the primary binder and adhesive in the fill mixture. It is clear, photochemically stable, and has a molecular weight of 13,000 (Union Carbide 1982 and 1989). Its primary industrial application is as a chewing gum elastomer.[6] It is soluble in a variety of organic solvents and has well documented reversible characteristics which have been reviewed (Feller et. al. 1978). The softening point of PVA AYAC is 160°F (71°C) and it must be heated above 450° F (230°C) before it will begin to char.

This resin, like the other PVA resins, does not have a specific melting point, rather, it softens as the temperature rises until it eventually becomes a viscous flow. This is based on the fact that PVA resins are blends rather than a specific molecule with a specific melting point.[7] Its glass transition temperature (Tg), which has been defined as "the temperature at which a material changes from a solid, glassy state to a softer rubbery state", is about 61°F (16°C) (Schilling 1988).

The Ethylene-acrylic acid copolymers (EAA) are materials of low molecular weight (2000-2500) which are used as additives in adhesives, coatings, or in hot melt adhesives (Domine and Schaufelberger 1977). They are also emulsifiable in water-based systems.[8] The softening points are below 221° F (105°C) for A-C 540 and 203° F (95°C) for A-C 580 (AlliedSignal 1993). These resins have some solubility in acetone; and there is no free acid present in the EAA copolymers. Their acrylic acid component gives these waxes increased toughness and better adhesion to polar substrates.[9] To the wax-resin they lend both translucency and toughness.

At elevated temperatures polymers are susceptible to thermo-oxidative degradation; hot melt adhesives are particularly prone due to the method of their application. The addition of an antioxidant prevents yellowing of the wax-resin at high temperatures, either while melting or on the spatula tip.

There are two basic classes of stabilizers: primary or chain-terminating antioxidants and secondary hydroperoxide-decomposing antioxidants (Ciba Geigy 1990 and 1993; Earhart 1994). Primary antioxidants have also been described as radical scavengers because they react with peroxy and alkoxy radicals to form phenoxy radicals which are relatively stable (de la Rie 1988a, 1988b). The Irganox 1076, a primary sterically hindered phenolic antioxidant, was chosen for this formula because its melting point of 50-55°C is below the formulating temperature of the blend. Irganox 1035, another primary hindered phenolic antioxidant, has also been used in this formula. It has a sulfur bridge that provides peroxide decomposition capability in addition to standard antioxidant functionality. It is also a slightly larger molecule than Irganox 1076, and has a melting point of 145-154°F (63-68°C).[10]

As Burke (1983) observed, the ratio of components can be altered according to the desired qualities of the fill material. He increased the PVA AYAC content to harden the blend, to increase gloss, the melting point, and viscosity. He noticed that increasing the EAA content increases the waxyness of the blend but also decreases the cold flow, while simultaneously decreasing the melt viscosity. AC 580 is softer and more adhesive than the A-C 540; varying the 540/580 proportion, therefore, affects those properties. John Burke also experimented with adding a UV-absorber, which appeared to prevent yellowing, but the UV absorber (Uvinul D-49) used by him was strongly colored and imparted a slight tint of its own.

Preparation of the material

The following formula has been used for numerous treatments in several conservation laboratories:

9 parts PVA AYAC
3 parts A-C 540
1 part A-C 580
1/2% wt. Irganox 1076 or 1035

Starting with the PVA, these materials are melted together on a hot plate, wax pot, or in a well-controlled oven, at the lowest possible temperature. When the PVA is melted, the antioxidant and thermal inhibitor Irganox is added. The EAA resins are slowly stirred into the hot melt. The components are not completely miscible, rather they are slightly incompatible. Discoloration and separation can occur if the temperature is too high or if the mixture is not stirred enough. Separation is easily recognizable, for the PVA floats in translucent bubbles on the surface of the mixture; stirring will reverse this situation. If no pigments or filler are added, the mix becomes a translucent, light grayish white, somewhat glassy material. Dry pigments can be added as needed (Figure 2). If the treatment requires the use of small strips of cold wax-resin, the melted mass can be poured into strips on Mylar[11] or glass and allowed to cool (Figure 3).

Examples of treatment application and evaluation of existing fills

The break edges to which the fill is to be applied must be coated with a primer, which consists of a brushable solution of PVA AYAA, 10-30% in organic solvents, wt./vol. This PVA primer will soften as the warm wax-resin is applied to the object and will form a bond with the fill; without the primer the wax-resin fill will not adhere well to the object. In some cases, due to the shape of the break edges, the fill will be locked further into the area of loss. Generally, the less physical the grip, for example in shallow losses or narrow gaps along break edges, the more thorough the primer coating needs to be and the warmer the fill needs to be when introduced.

The wax-resin can be manipulated in a number of different ways. Many types of losses can be filled using sticks of wax-resin softened with a hot air gun (Figure 4) or a heated spatula, pressing the material into the primed area to be filled. Slight warming of the object, if at all possible, prevents cold joint. For example, an Old Kingdom Egyptian spouted jar at the Museum of Fine Arts, Boston (MFA 72.557), carved from Egyptian alabaster (i.e. calcite) was treated

(Figure 5). It was broken in two pieces, and had a loss at one side of the vessel. Sticks and sheets of the fill material, colored to match the base color of the jar, were melted against the primed break edges after cleaning. As the material cooled slowly, more layers were added and the fill was smoothed with a heated spatula. It was easiest to overfill and continue final shaping mechanically. The wax-resin was sanded, and buffed and polished with a cotton cloth and Novus Plastic Polish No. 2 to match the surface luster of the original stone (Figure 6).[12] A high gloss can be obtained by polishing a fill that has been made scratch free by sanding with increasingly fine sand papers. Full compensation of the loss was required using acrylic emulsion paint to continue a dark stain and some superficial white spots from the original surface (Figure 7).

A Roman marble sarcophagus at the Los Angeles County Museum of Art (LACMA 50.37.11) had numerous gaps along old break edges that needed to be filled in 1982 (Figure 8). The wax-resin was applied to the primed stone edges in numerous areas with a heat spatula. The fills have been monitored since and have shown no signs of yellowing or cold flow, even at in vertical sites or at an overhang such as the underside of the rim (Figure 9 A & B).

Sometimes a loss is so large that it requires separate construction and attachment with a different adhesive than the primer. Larger losses can be cast, as was done on an Egyptian Old Kingdom offering table (MFA 11.2394) in preparation for a special exhibition on funerary art "Mummies and Magic" at the Museum of Fine Arts in 1988 (Figure 10). This object was carved from a single piece of calcite, which was characterized by bands of different color, ranging from white to amber, and from opaque to translucent. The offering table was to be displayed elevated on an ancient ceramic stand. Light shining through the 1/2 inch thick veined top was to display the quality of the stone.

The top of the offering table was broken into four pieces; one third of it was lost and needed to be replaced. Plaster and other opaque materials would not fulfill the requirements, and an alternative to polyester and epoxy was sought. A large amount of the wax-resin was prepared and colored to match the ochre base color of the stone. The fill was initially cast as a thick monochrome piece within the break area, but was separated from the stone by aluminum foil. It was further molded with a hot spatula (Figure 11). In order to recreate the opaque white veining of the stone, grooves were carved into the ochre fill section, continuing the original bands. These were then filled with matching white opaque wax-resin, applied with a hot spatula.

These bands were slightly overfilled and the cooled surface was then shaped with sharp tools and sandpaper. Given the large size and weight of the fill section, a bond formed by PVA alone did not seem practicable. The fill was therefore adhered to the reconstructed stone table fragments with a two-component epoxy resin (Epo-Tek 301-2)[13] after the break edges had been coated with Röhm & Haas Acryloid B-72 (Figure 12). The object has been on display in the MFA since 1988. While the color has not changed visibly, the fill has sagged noticeably (fig. 13). This certainly reveals the limitations of this material. If the treatment were to be repeated, perhaps it might benefit from a laminated fill incorporating a translucent core of another, more rigid, material or dowels, to which the wax-resin would be applied.

Another limitation of the material is that the wax-resin cannot mask underlying dark materials. This problem was encountered during the treatment of a group of nineteenth century white marble sculptures, recently acquired by the Chrysler Museum of Art, Norfolk, VA. Many of the sculptures had been previously restored. Large losses had been compensated with plaster and polyester resins cast in place. The plaster compensations crystallized in the stone, causing the break edges to become sugary and friable and, therefore, had to be removed. The plaster fills were replaced with removable subsurface Pliacre Epoxy Putty fills[14], grey in color, over which the wax-resin was applied (Figures 14 & 15). The polyester fills aged to a dark greenish yellow color. Because it was cast directly onto the object, the resin migrated into and catalyzed within the stone, resulting in an irreversible interior dark band. Since the polyester fills could not be removed, they were mechanically pared down and recoated with the wax-resin to more closely simulate the appearance of the stone.

In both instances where a dark underlying core existed, such as the old polyester fills or the detachable Pliacre Epoxy Putty subsurface fills, the darker core material will remain visible as a shadow inside, even if covered with a thick layer of wax-resin. This problem can be somewhat alleviated by using a white epoxy putty such as Milliput superfine epoxy putty[15] as a base for the wax-resin fill.

Using the same method, any number of natural stones can be imitated. Differently colored and opaque patterns can be alternated to achieve effects of depth, or to imitate granular or speckled stones.

Notes on aging properties of the fill material

The PVA component in the wax-resin has been shown to be a relatively stable material and was classified by Feller (1978) as a class A material [16]. When Burke conducted the blue-wool test on the A-C 540 , he found that it actually bleached slightly.

While one fill of extreme size has changed its shape all the others have remained apparently unchanged over the course of a decade. We do not know the glass transition temperature of the fill material, but the combination of polymers probably affects the Tg of the components. The Tg of the PVA goes up slightly and the melting point of the EAA goes down. It has been suggested that fillers such as pigments and marble powder may behave like tiny hurdles that the polymers have to move around which slow them down (Schlumpf 1990). To further investigate the Tg of the material a batch of pure AYAC and a batch of the fill material were made in the Objects Conservation Laboratory at LACMA, and placed in dated containers on January 10, 1994, where they are being be monitored. The PVA has already begun to move but the wax-resin has not. Another test being conducted at LACMA with a starting date of April 15, 1995 involves placing a 50 gm weight on a block of wax-resin to see if it displaces the resin. No movement has occurred to date.

Degradation of polymers is complex and depends on numerous factors (McNeill 1992). Certainly, the ongoing tests described above are rudimentary, although they give some indication of whether or not the wax-resin moves relative to the individual components. To date we have only observations on color fastness and physical stability of the fill material.[17] Certainly, many more tests will have to be done to examine the possible degradation of the material.

Conclusions

This wax-resin mixture has been useful for the compensation of losses in translucent materials, especially stones such as alabaster, calcite, marble, anhydrite, and diorite. The ease of its application makes it a particularly attractive choice. The wax-resin is used best on losses which allow for a large contact with the original, primed surface, and on losses that are thicker than approximately 1/16 ". Shallow losses and small gaps, for example between break edges, proved to be somewhat difficult, as the fill is easily pulled out during surface manipulation. Similarly, the wax-resin seems unsuited for large, unsupported fills. The fills remain easily removable at all times and do not penetrate the original material, but its aging properties have to be further investigated. Further experimentation with mixture ratio and with other resins, could lead to improved results.

Acknowledgments

Thanks to John Burke and Steve Colton for discussing their treatments and research, and for supporting this publication. The late Jane Carpenter should be remembered especially for introducing the wax resin to the Straus Center for Conservation and Technical Studies, Harvard University Art Museums. Carol Warner, National Park Service, was first to experiment with the material and to use it at the Museum of Fine Arts. Arthur Beale and Dr. Timothy Kendall, MFA, and Dr. Pieter Meyers, LACMA, helped to edit the paper.

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Endnotes

1. The term "wax" in "wax-resin" is used throughout the article in reference to Ethylene acrylic acid copolymer (EAA). Wax is a rather loose term applied to a variety of substances consisting of hydrocarbons and that share a number of characteristics such as "waxy" feel. Furthermore, most of them are relatively solid at room temperature, liquefy with increasing temperatures, and will solidify when cooled again.

2. Many conservators have experimented with other thermoplastic resins as well, including PVAs and Rohm & Haas Acryloid B-72.

3. Polyvinyl Acetate resins PVA AYAA and AYAC are manufactured by Union Carbide Corporation, Specialty Chemicals and Plastics, Old Ridgebury Road, Danbury, CT 06817, phone: (203) 794-5300.

4. Ethylene-Acrylic Acid Copolymers A-C 540 and 580 are manufactured by AlliedSignal Inc., A-C Performance Additives, P.O. Box 2332, Morristown, New Jersey 07962-2332, phone: (201) 455-2145 and 1 800-222-0094, fax: (201) 455-6154

5. Irganox, Antioxidant and Thermal Stabilizer, is manufactured by Ciba-Geigy Corporation, Seven Skyline Drive 3, Hawthorne, NY 10532-2188, phone: (914) 785-4461 and 1 800-431-1900, 800-431-2360 (orders).

6. Conversation with Glenn Reid, Technical Consultant, Union Carbide, December 1, 1994.

7. Ibid.

8. Conversation with Mark Huff, AlliedSignal Inc., September 7, 1995.

9. John Burke is currently exploring further conservation applications of these waxes.

10. De la Rie (1988a) cautioned that the use of sulfur compounds, such as Irganox 1035, in metal ion containing materials might lead to darkening.

11. Mylar polyester film, can be obtained from Conservation Materials Ltd. P.O. Box 2884, Sparks, NV 89431, phone: (702) 311 0582, fax: (702) 331 0588.

12. Novus Plastic Polish No. 2 is manufactured by Novus Inc., 10425 Hampshire Avenue South, Minneapolis, MN 55438, phone: 1 800 548 6872.

13. Epo-Tek 301-2 is available from Epoxy Technology Inc, 14 Fortune Drive, Billerica, MA 01821, phone: (617) 667 3805.

14. Pliacre Epoxy Putty is manufactured by Philadelphia Resins Corp., 20 Commerce Drive, Montgomeryville, PA 18936, phone: (215) 855 8450.

15. Milliput Superfine Epoxy Putty is manufactured by The Milliput Corp., Unit 5, The Marion, Dolgellau, Mid Wales LL40 1UU, U.K., phone: x (1341) 422562.

16. Feller published a grading system for conservation materials and their expected photo-stability based on the blue-wool test using the International Standard Organization R105 Blue wool standard #6 for photochemical stability in which the degree of fading of a sample of blue wool has been quantified. Under most conditions, conservators prefer to use a Class A material which, based on annual museum light levels should last for 100 years or better or suffer no more than 20% loss of its essential properties in a recent conversation,

17. Burke has observed that some of the earliest samples he used have yellowed. This he attributes either to lack of an antioxidant or to over-heating at the time. He also subjected samples of the wax-resin to accelerated aging and then separated PVA from EAA by melting. Burke noted that it appeared that the PVA component in fact had yellowed. Based on this observation Union Carbide recommended adding a cycloaliphatic epoxy resin (ERL-4221, Union Carbide) as a stabilizer to the PVA. Samples of wax-resin prepared with this additive do not seem to have yellowed over 10 years.

Figure 1. The different components that constitute the wax-resin fill material.

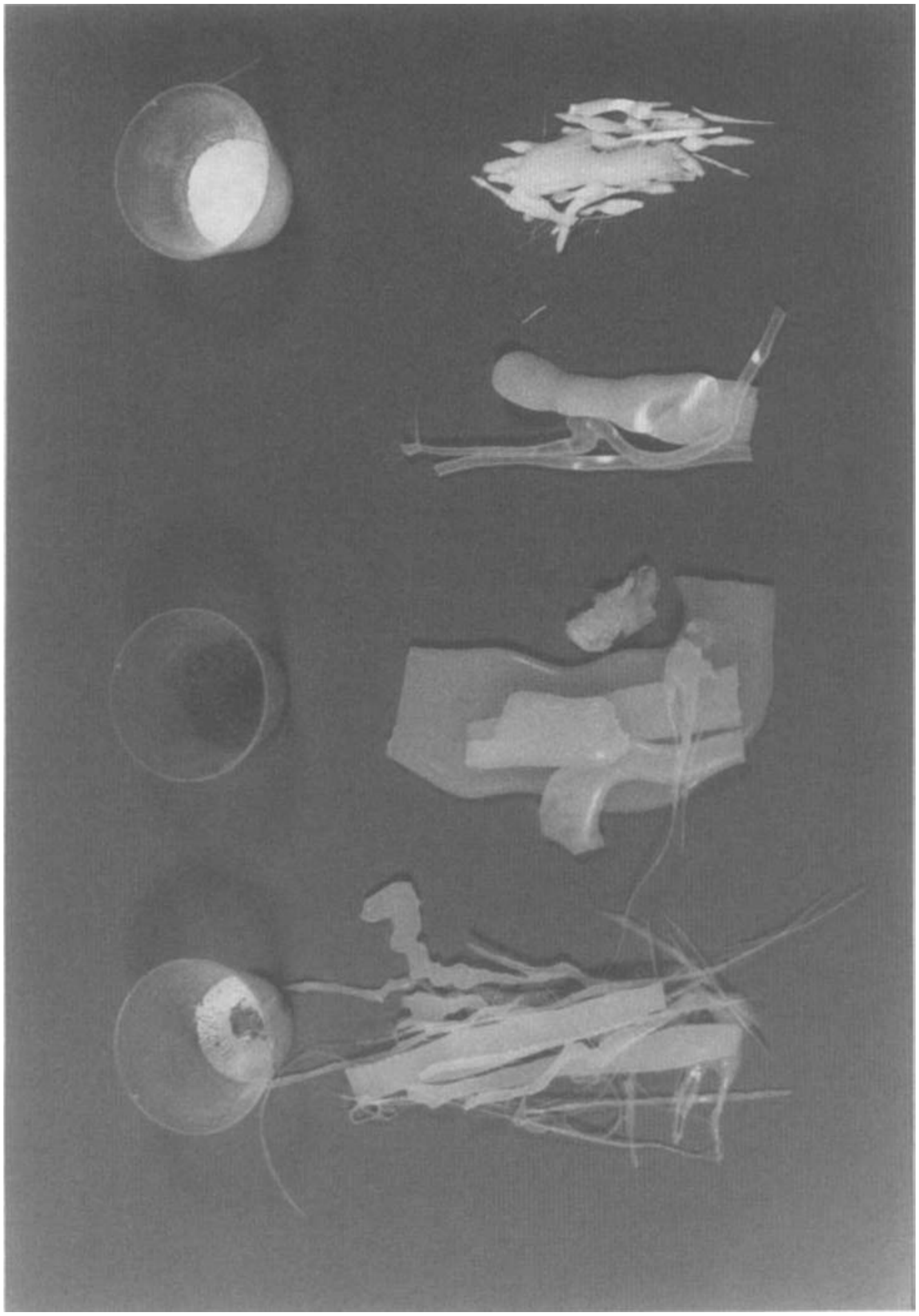

Figure 2. Dry pigments can be used to obtain any desired color and opacity.

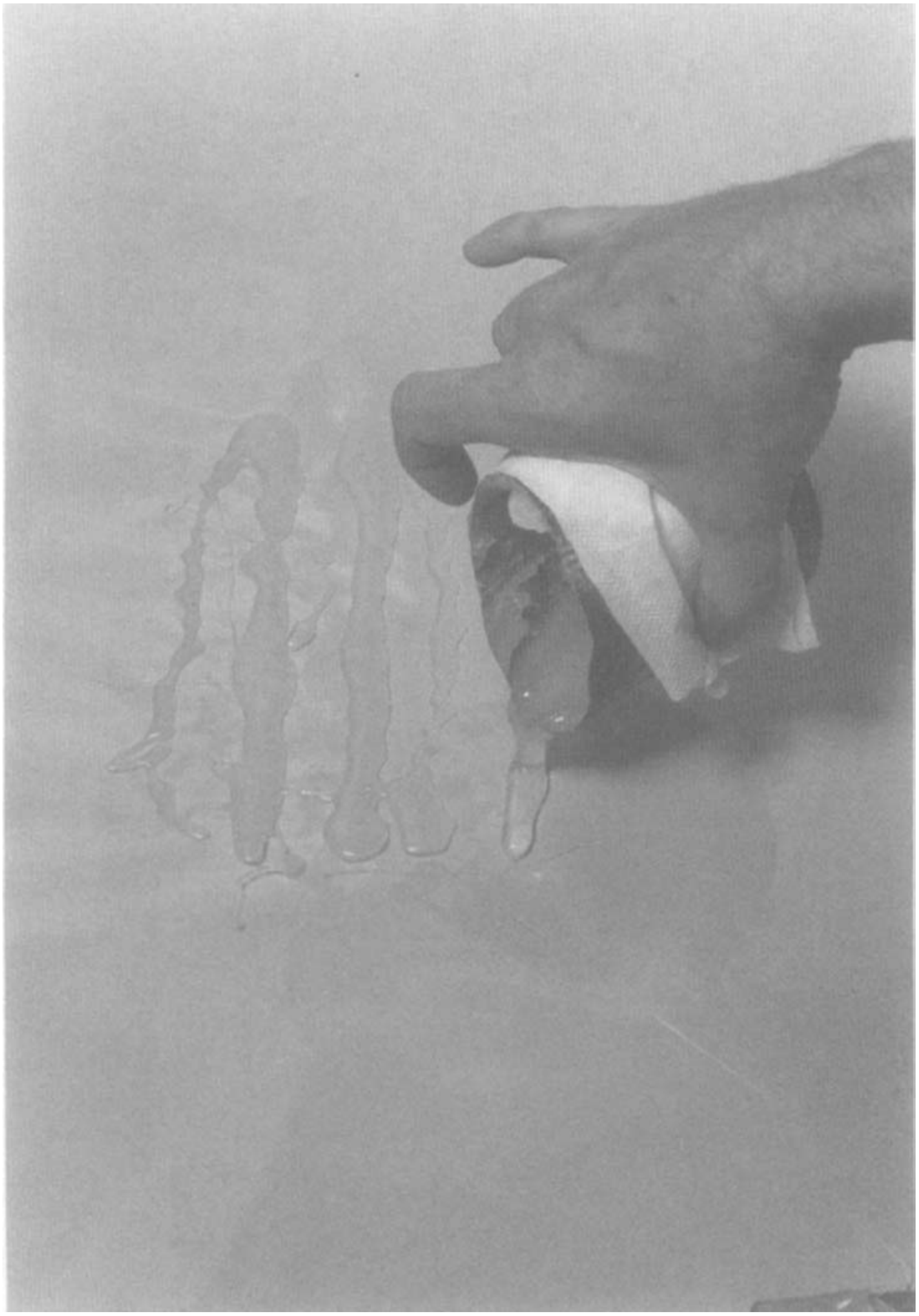

Figure 3. The melted fill is poured onto Mylar where it hardens forming thin strips.

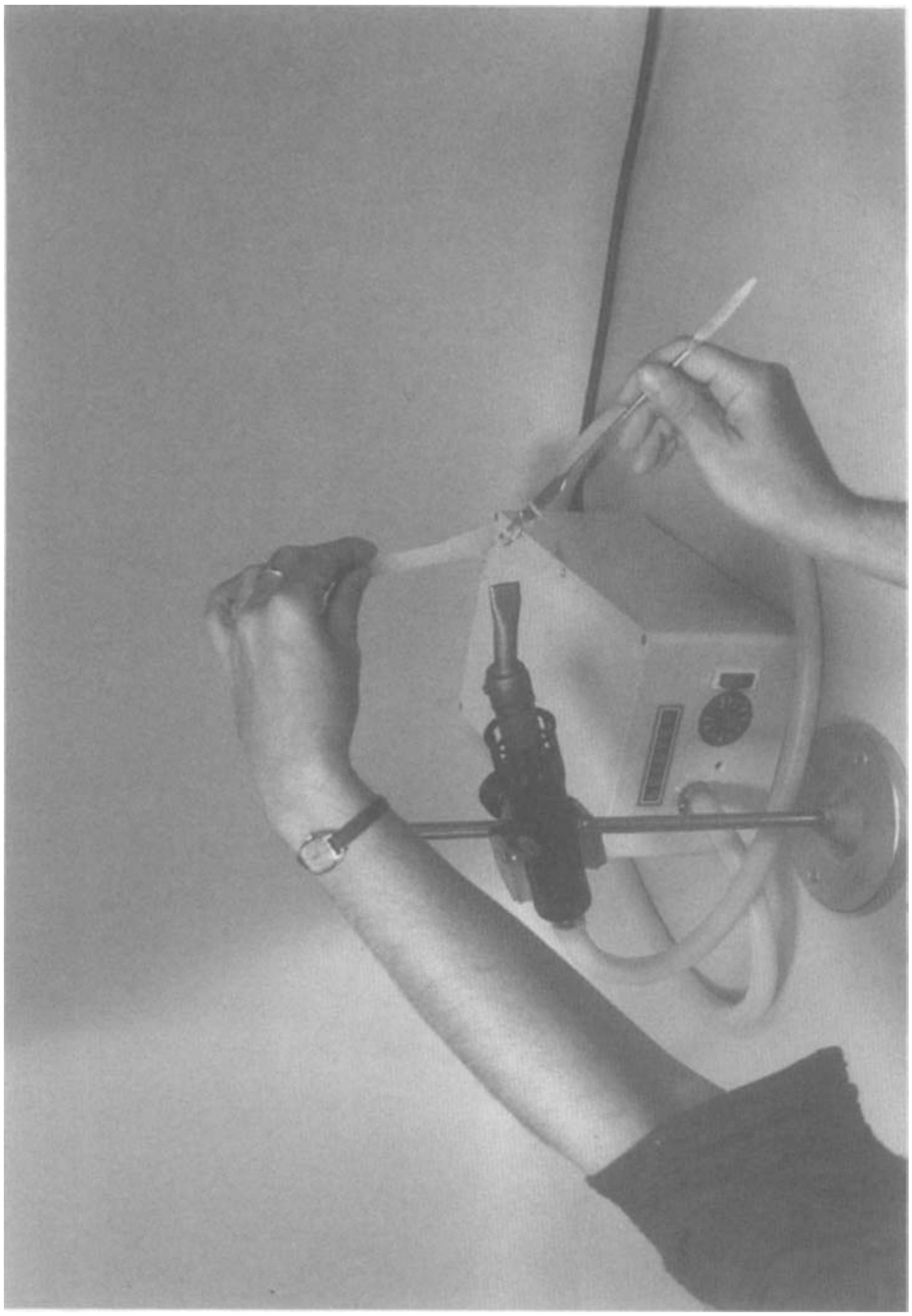

Figure 4. Hardened wax-resin sticks can be softened with a hot air gun.

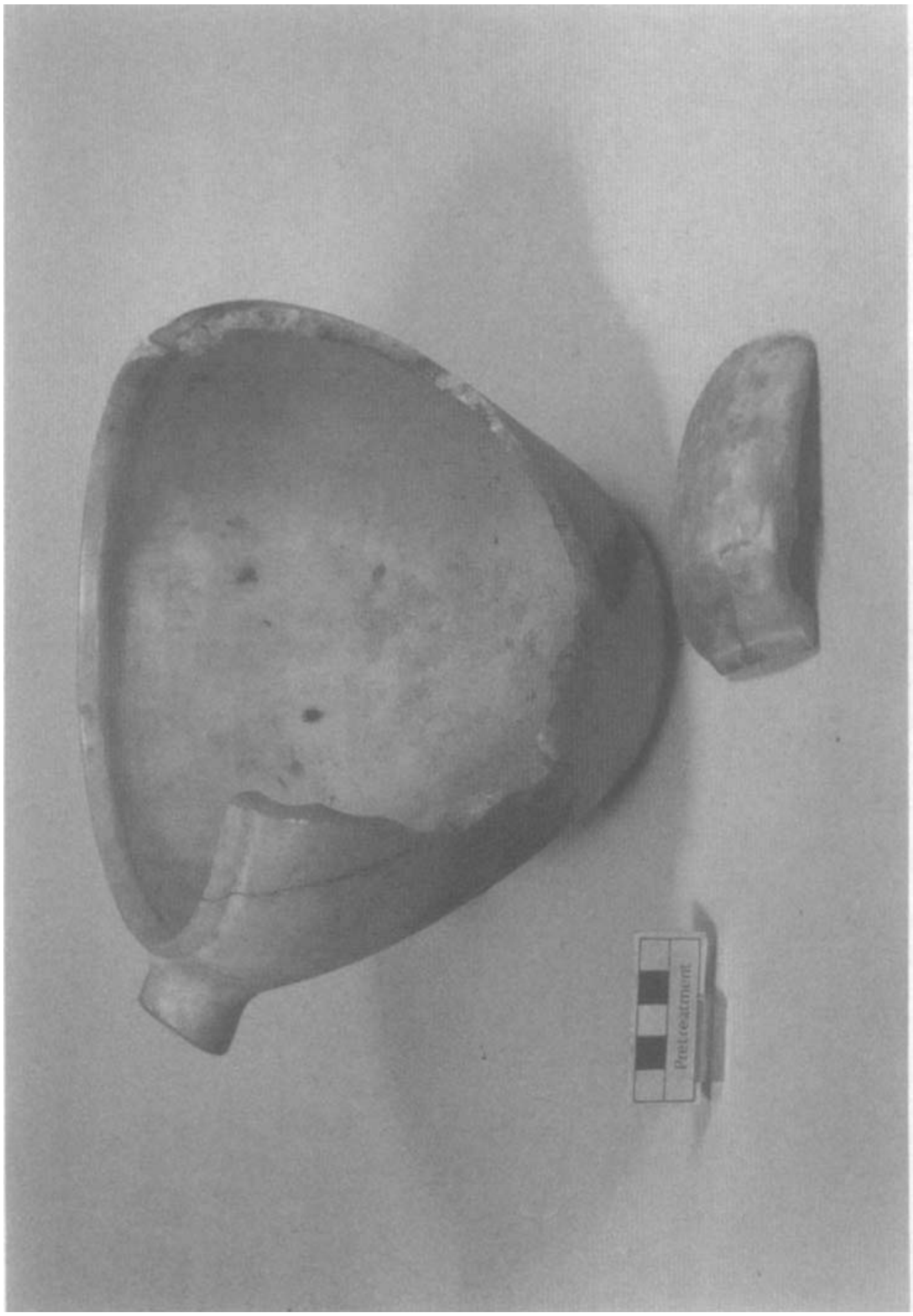

Figure 5. Old Kingdom spouted bowl (MFA 72.557) before treatment.

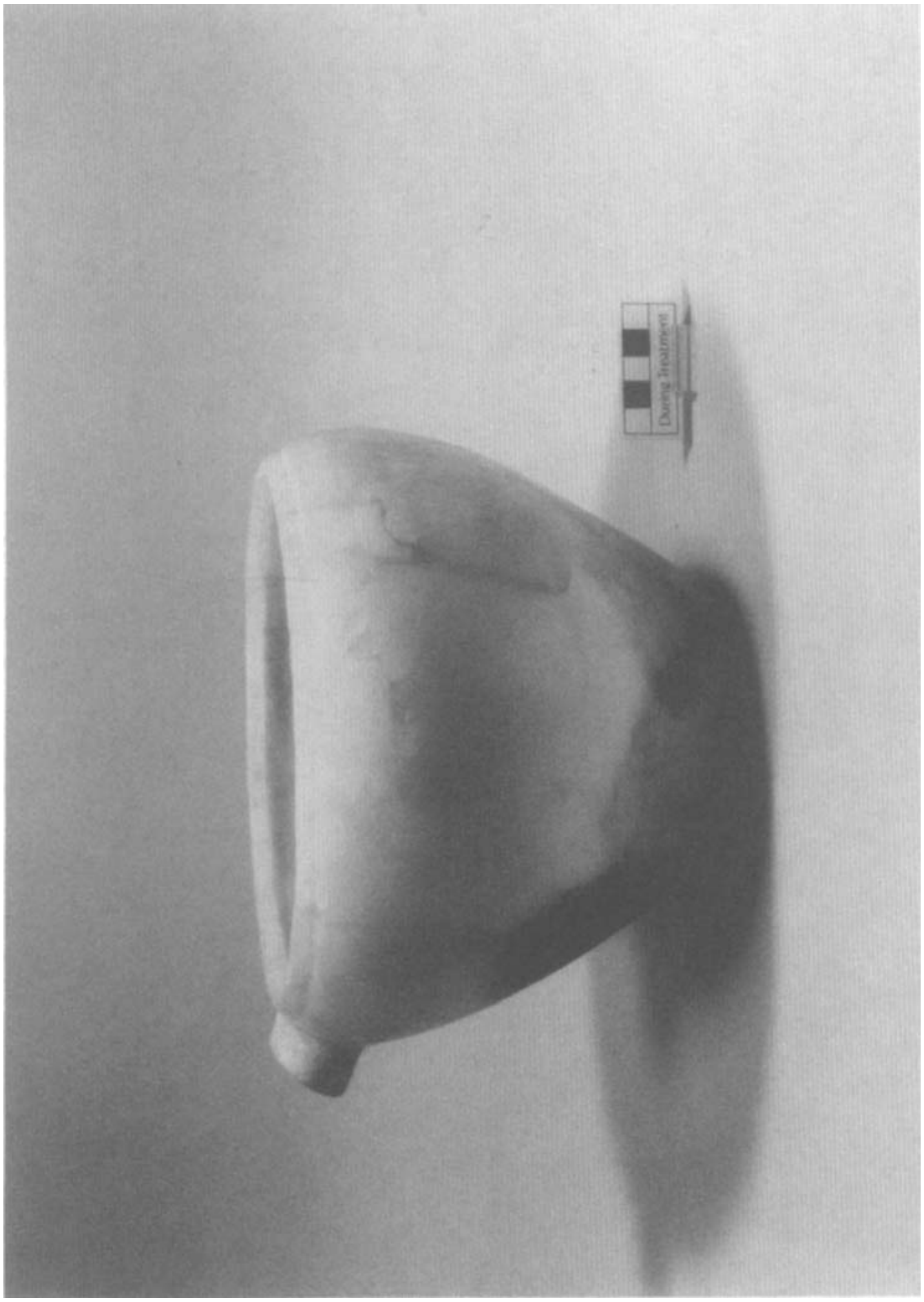

Figure 6. Wax-resin fill in bowl (MFA 72.557) prior to inpainting.

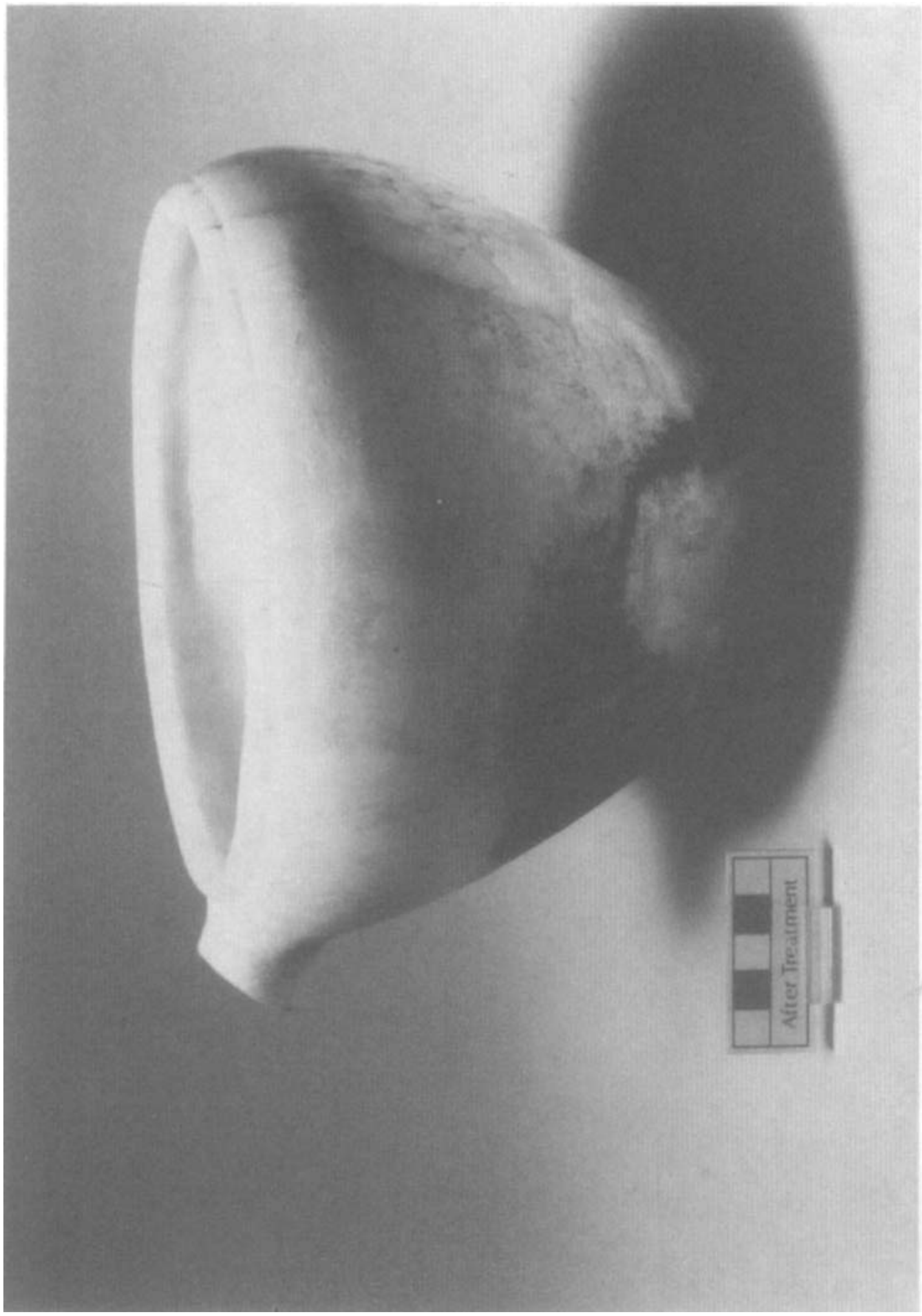

Figure 7. Bowl (MFA 72.557) after polishing and inpainting.

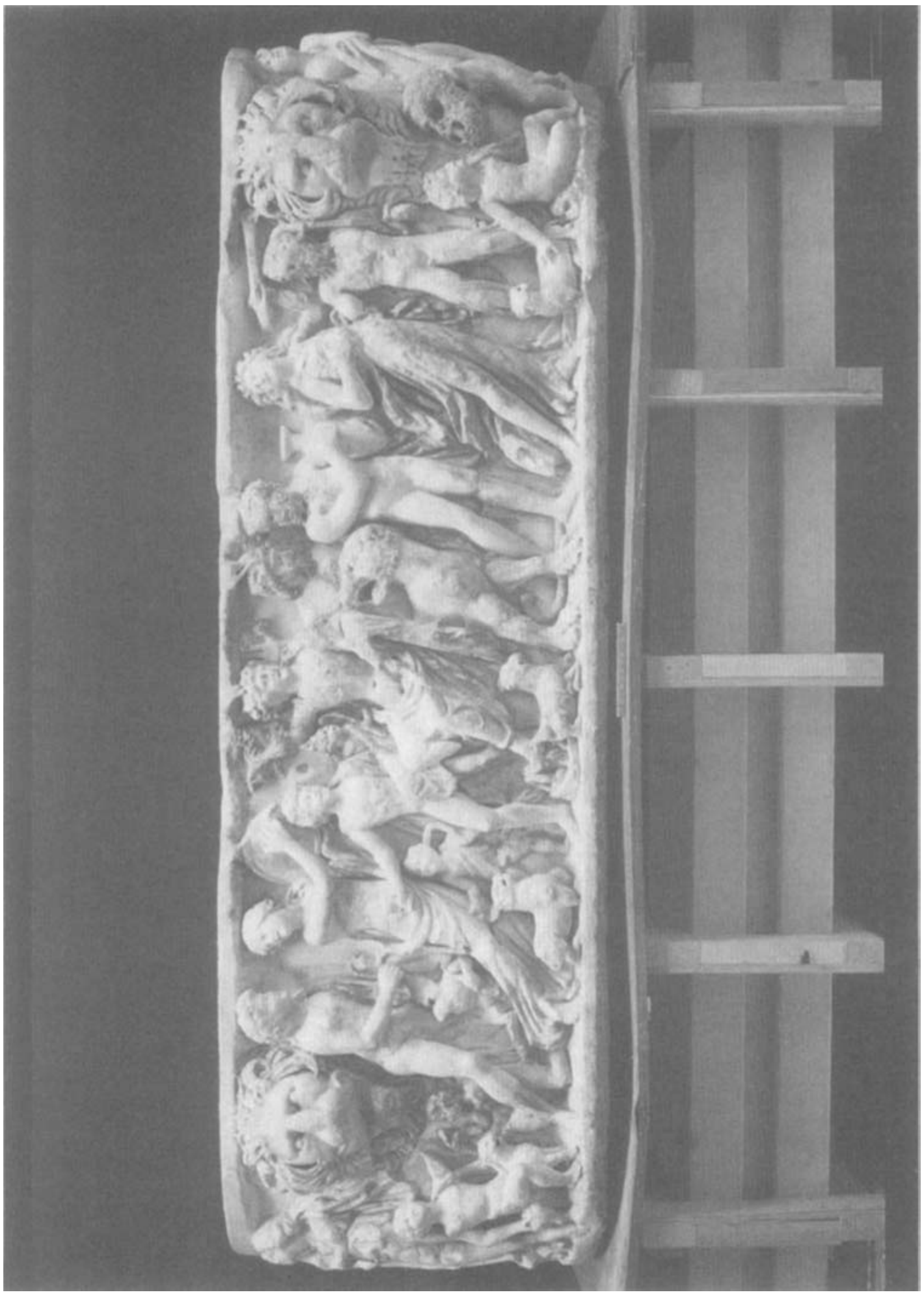

Figure 8. Overall view of Roman sarcophagus (LACMA 50.37.11) after treatment in 1982.

Figure 9A. Area where the wax-resin was applied on both vertical and an overhang in 1982 (LACMA 50.37.11).

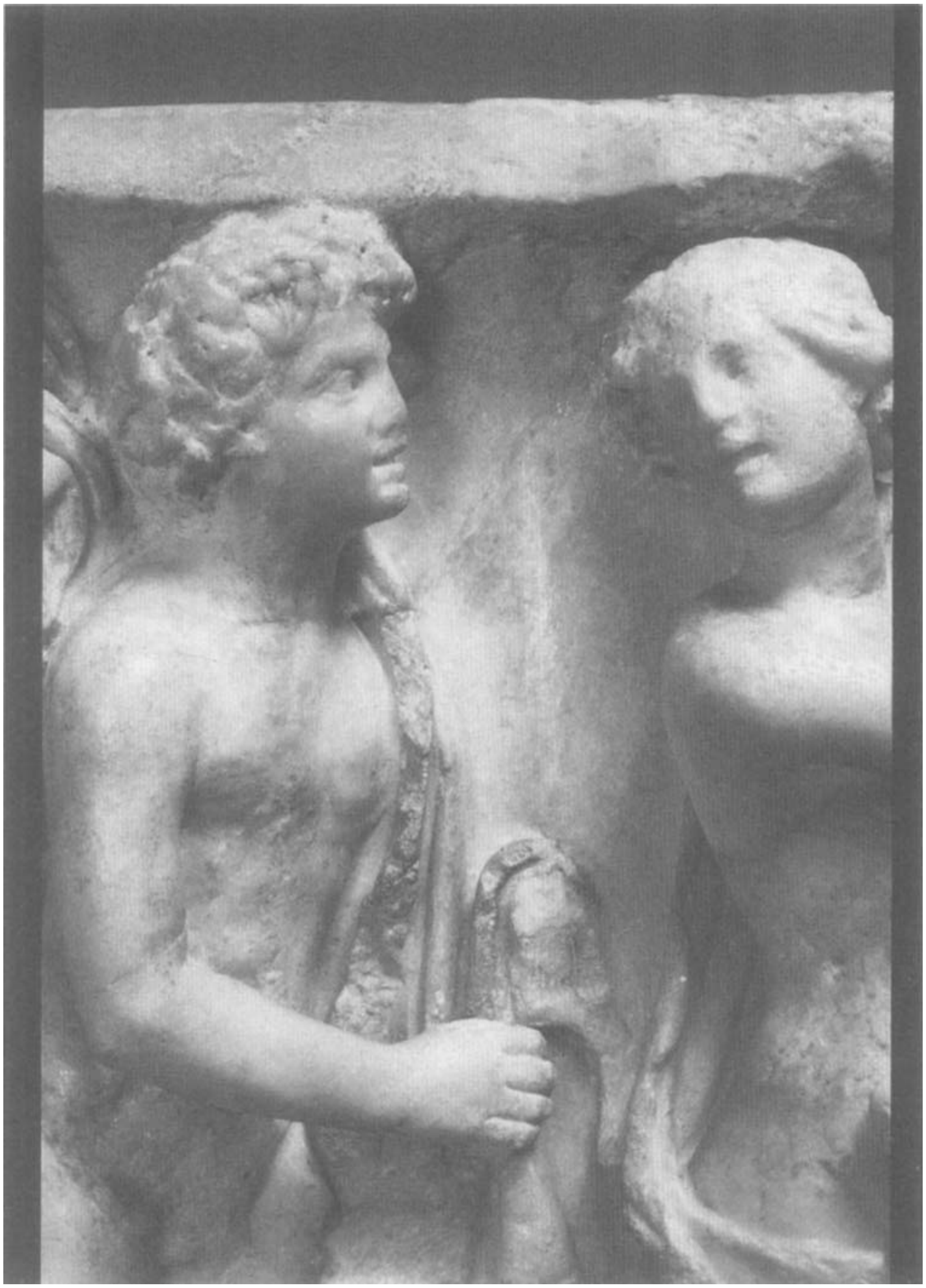

Figure 9B. Details of Figure 9A, taken in 1995.

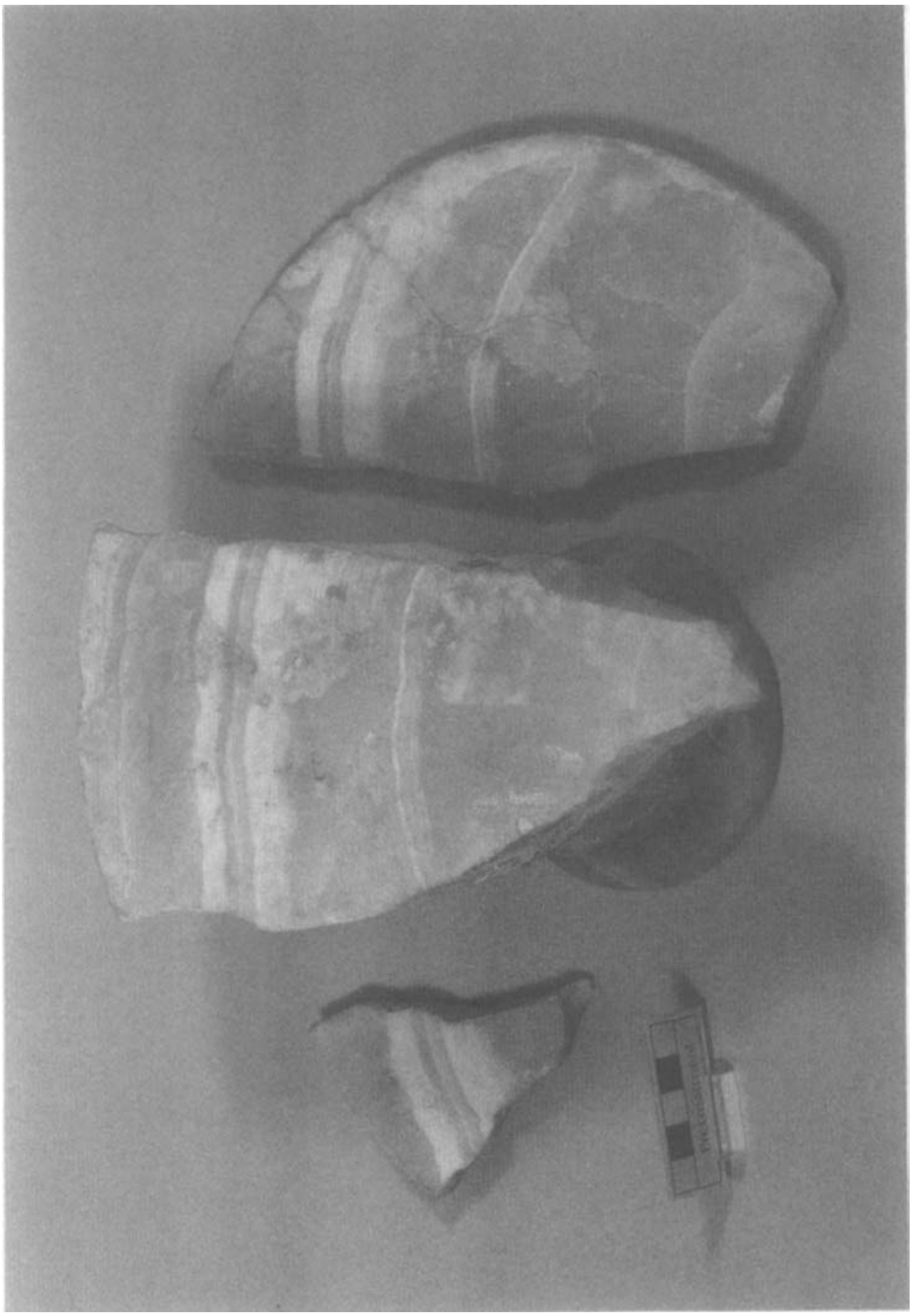

Figure 10. Old Kingdom calcite offering table (MFA 11.2394) before treatment.

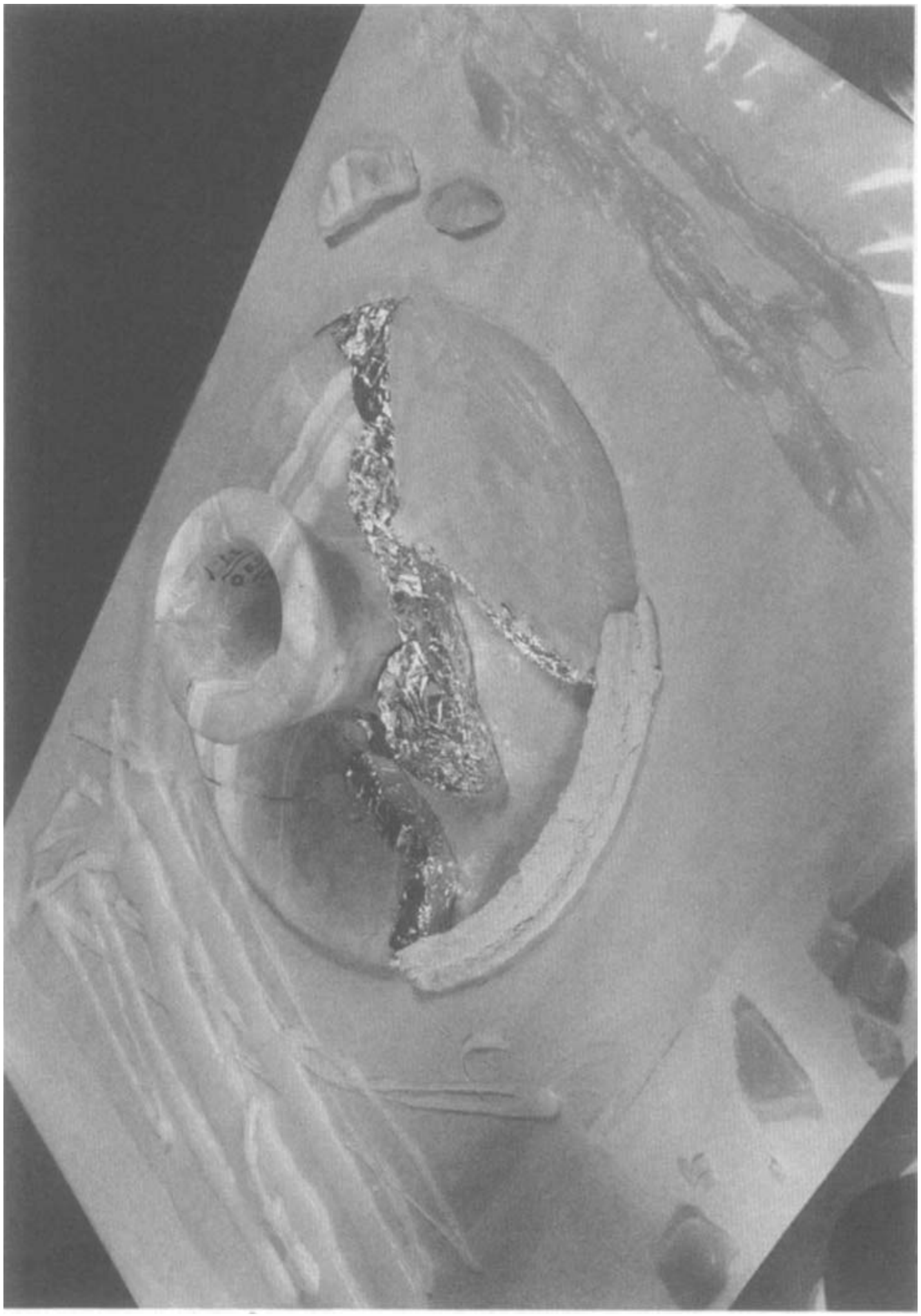

Figure 11. Offering table (MFA 11.2394) during filling.

Figure 12. Offering table (MFA 11.2394) after treatment in 1988. Note the fill on the left side of the table.

Figure 13. Offering table on its pottery stand (MFA 11.2394) in the Museum's galleries in August 1995. Note the sagging right side of the table.

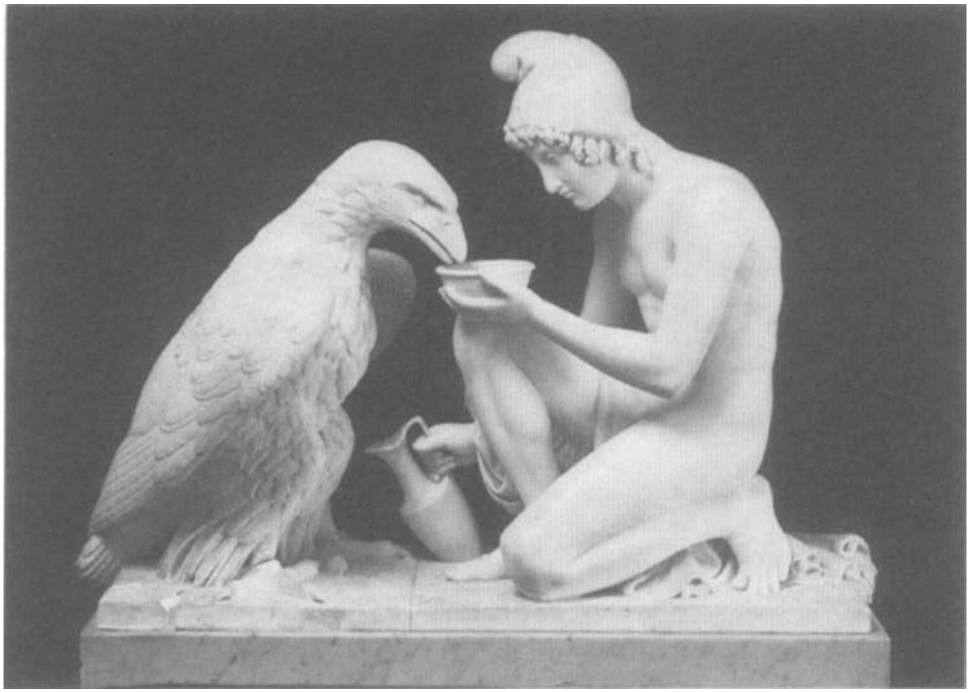

Figure 14. Ganymede and The Eagle, 1817, Bertel Thorwaldsen, The Chrysler Museum of Art Norfolk, VA, (86.525). Gift of James H. Ricau and Museum Purchase. Before treatment.

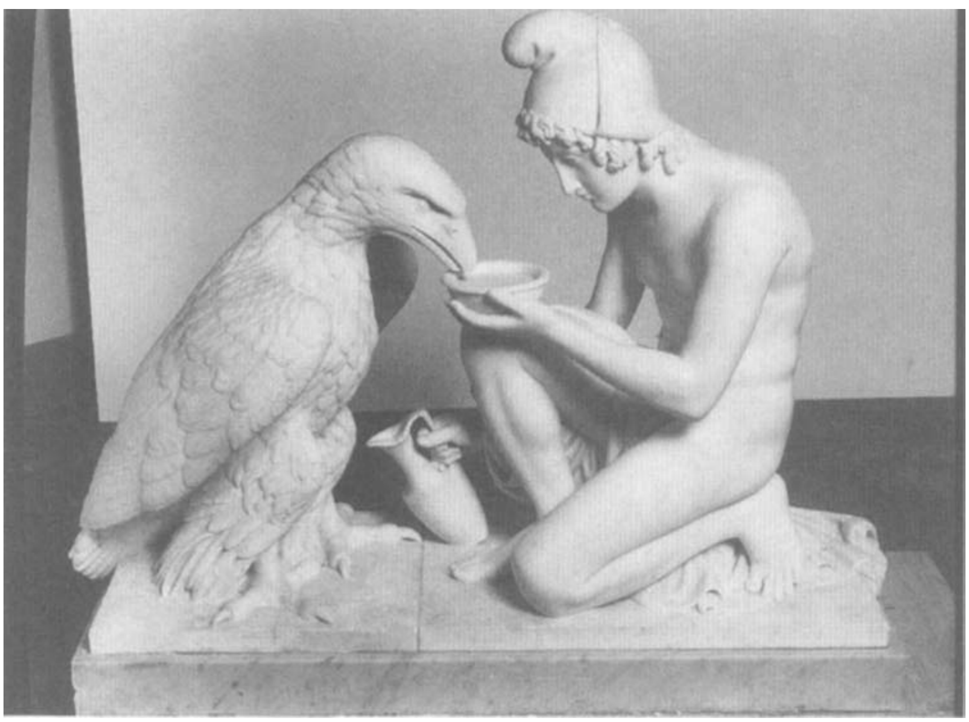

Figure 15. Ganymede and The Eagle, 1817, Bertel Thorwaldsen, The Chrysler Museum of Art Norfolk, VA, (86.525). After treatment.

HEAT-FUSED RESINS OR "RESIN STICKS" FOR USE AS REINFORCING ELEMENTS OR DOWELS IN THE STRUCTURAL TREATMENT OF OBJECTS

Peter S. Champe

As one solution to the problem of structural repairs require dowels or rigid reinforcing elements or irregular size or shape, I have had success in using heat-fused pellets of adhesive resin, or "resin sticks". Resin sticks are easily made from pellets of PVA or methacrylate resins using a heat source such as a Bunsen burner or hot air gun to fuse them into a coherent mass. Resin sticks can be made to virtually any size and then molded to the desired shape.

In the reattachment of the highly deteriorated wooden arm of a Northwest Coast Indian beaver headdress in the collection of the National Museum of the American Indian (1/8944), a difficulty arose in the fact that the break occurred at the elbow which described a roughly 90 degree angle. The angle of the join suggested the use of a material which could be easily shaped to describe this angle and was strong enough to act as a dowel. A resin stick of Acryloid B-72 was made to the desired thickness and shaped to the correct angle. This was used successfully as a dowel, bridging a significant area of loss and rejoining the arm to the beaver.

Another treatment using this method involved the reattachment of the wing of a small 12th-century Limoges copper-gilt angel in the collection of the Metropolitan Museum of Art (58.110). The configuration of the piece required that a small splint rather than a dowel be used in the reattachment of the wing. As the splint had to be quite thin, different resins were carefully considered for characteristics of strength and rigidity. The methacrylates Acryloid B-72, B-48N and B-67 were found to be too brittle while the PVA resins AYAF and AYAT were found to be too flexible. PVA-AYAA proved to possess the best combination of rigidity and strength. Due to the small size of the resin splint used in this treatment, it was necessary to insert a strip of copper into the resin for further reinforcement. This was easily accomplished by heating the copper and then pressing it into the resin after it was in place. The PVA splint was attached to the copper figure using Acryloid B-48N in toluene.

Plexiglas dowels can be used in a similar way and are stronger than heat-fused resin-sticks. The extrusion processes in the manufacture of Plexiglas rods establishes polymeric alignment in an increased strength over heat-fused resins.

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TESTING ERASERS USED TO CLEAN MARBLE SURFACES

Jane Williams and Julie Lauffenburger

Many conservators already use erasers in electric erasing machines to clean stone surfaces, but there has not yet been a published or comprehensive evaluation of the effect of this method on stone, or of individual erasers sold particularly for use with the electric machines. Erasers offer an alternative for cleaning stone objects whose metallic inclusions or soluble salt content make them vulnerable to damage by aqueous treatments. Eraser cleaning also offers a high degree of control. The effect of erasing can be evaluated instantly and the level of cleaning can be carefully controlled by the selection of the eraser, by the speed and pressure of electric erasing or by the use of a hand-held eraser. Because of this high level of control erasing may be used in conjunction with aqueous or solvent-based treatments to clean localized areas of persistent dirt.

Most of the published studies dealing with eraser cleaning have evaluated a range of hand-held erasers and their effect on paper. A 1982 article by Pearlstein, Cabelli, King and Indictor studied the composition and aging of erasers and their effect on paper. Moffatt and Laver published a CCI analytical report on the composition and aging of nineteen erasers and other dry cleaning products and the quantity of residue, in the form of eraser particles, they leave on paper. The authors of both studies suggest useful guidelines for testing erasers and their effects on different substrates. In the last two years Eleanora Nagy at CCI has published two articles discussing the use of electric erasers to clean a variety of fire-damaged, soot-covered material such as lacquered wood, porcupine quill and bark, and enamel on brass.

The primary goal of this study was to determine whether the action of the electric eraser abrades or otherwise alters the surface of the stone. This study also explored whether erasers leave residues on the surface and if so, how these residues might be expected to behave with the passage of time. A group of erasers were selected that are readily available in art supply stores for use with electric drafting eraser machines. From Faber-Castell, which markets a wide variety of machine eraser strips, three erasers were selected that were recommended by Faber-Castell and by other conservators as their least abrasive erasers. The single erasers strips, both white vinyl, marketed by Koh-i-noor and Staedtler when this study began in 1992 were also included.

Eraser Composition and Aging

The first part of the study focuses on the compositions and characteristics of the erasers. Information was collected from the manufacturers on the composition of the erasers. Because this information can be incomplete, incorrect or misleading, it was compared to elemental analyses of the inorganic constituents of the erasers using SEM-EDS (Fig. 1). Mark Wypyski at the Metropolitan Museum of Art conducted all SEM analyses. Reactivity and aging tests were also used to study the materials in the erasers. The erasers were analysed using FTIR (Fourier transform infra-red spectroscopy) to identify their organic constituents. George Wheeler and Dora Hanil conducted all FTIR analyses. Because manufacturers may alter the compositions of their products at any time, it is important to note that the erasers studied here were all purchased in 1992.

The Faber-Castell no. 75 soft green and no. 76 soft pink for pencil have compositions based on vulcanized rubber and factice. The presence of these two components was confirmed by FTIR analysis. Factice is a mealy, white, vulcanized vegetable oil that softens the rubber. Both erasers contain diatomaceous earth as an abrasive and also are bulked with calcium carbonate. According to Faber-Castell, the only difference between the no. 75 and no. 76 is their color. The primary difference found with EDS analysis is that the soft pink eraser contains somewhat more silicon. The other three erasers, Faber-Castell no. 79, Koh-i-noor 287 and Staedtler 52705, are all vinyl-based erasers. High amounts of chlorine were detected in each of the vinyl erasers by EDS. FTIR analyses confirmed the presence of a dialkylthalate ester plasticizer in all three vinyl erasers. All three are bulked with calcium carbonate, which may also buffer the erasers from the hydrochloric acid released upon degradation of the PVC. The Koh-i-noor and Staedtler erasers also contain titanium, probably in the form of titanium dioxide. Incidently, since we began this study, Faber-Castell has introduced the Premium White Vinyl eraser (no. 88). This eraser was not tested for this study, but according to the manufacturer it differs from the original white vinyl eraser only by the inclusion of titanium dioxide. The Faber-Castell white vinyl eraser contains a small, but significant, amount of silica.

A variation of the Oddy test was used to evaluate the reactivity of the five erasers, to get an idea of how any eraser residue left on the stone surface might age and interact with other nearby materials. The erasers were placed partly in contact with polished coupons of silver, copper and lead and an iron nail in sealed glass containers that also contained a vial of tap water. The containers were placed in an oven at 40 degrees Celsius for four weeks. The two sulfur-containing, factice-based erasers generated a heavy layer of what appears to be black sulfide corrosion on the silver and copper coupons. These two erasers also induced the most corrosion on the iron nail, especially where the nail was in contact with them. None of the three vinyl erasers reacted strongly with any of the metal samples. The Faber-Castell white vinyl eraser did cause a very light corrosion film to form where it touched the copper coupon. The chlorine in the vinyl erasers does not appear to be released in significant quantities in the conditions of these accelerated aging tests.

Testing erasers on marble surfaces

The next part of the study evaluated the effect of erasers on stone surfaces, using one square foot Carrara marble tiles as the test surfaces. The tiles have one commercially-polished side and one side that retains a rough, saw-cut surface. Both of these surfaces were used in testing to help represent the range of marble surfaces that might be cleaned. The tiles were prepared by wiping them with lint-free cotton pads saturated with 1:1 deionized water and ethanol, followed by acetone. Each tile surface was divided in thirds: one as a control, one where the erasers were used hand-held and one where the erasers were used with the electric machine. The hand-held and machine erasing were each done for two minutes. One person did all the erasing for the tests, trying to maintain consistent pressure and working in parallel back and forth strokes without lifting the eraser. After erasing the surfaces were brushed with a soft brush to remove all visible eraser crumbs.

In each of the test areas visual observations and specular gloss readings were recorded before and after treatment. Specular gloss measurements were taken using a Dr. Lange Labor-Reflektometer at the Conservation Analytical Laboratory, Smithsonian Institution. Readings were taken in fifteen places within each test area and the reflectometer calculated the mean of the readings. No statistical difference in specular reflection was detected on any of the test areas after treatment. Because this method did not show changes under any test conditions, the specular gloss data are not reproduced here. This part of the experiments replicated the conditions of the tests of poultice materials on marble completed by Lauffenburger, Grissom and Charola. For future tests, George Wheeler has suggested using polished single crystals of calcite to detect more subtle changes in surface gloss.

When we examined the tiles with reflected light under a binocular microscope the only visual differences were found on the polished surfaces cleaned with the erasers containing diatomaceous earth. On the areas that were machine-erased with these erasers, dull streaks are visible across the erased surfaces with the naked eye. At 25x magnification the streaks are resolved into fine, parallel scratches. The scratching is only slightly discernible on the hand-erased polished surfaces and is not visible on the rough, saw-cut surfaces, probably because the scratches caused by the diatomaceous earth are much shallower than the saw marks. No visual difference could be observed at any magnification on any of the marble samples treated with the vinyl erasers. The small amount of silica present in the Faber-Castell vinyl eraser did not appear to cause any abrasion of the stone.

Additional smaller 1" x 2" samples were cut from the same Carrara marble tiles to fit into the vacuum chamber of the scanning electron microscope. On these samples, one half was left as a control and the other half was erased with an electric eraser for two minutes. Since the first tests results differentiated between the factice-based and vinyl-based erasers, one of each type was used to evaluate whether the SEM would provide useful information. The EDS attachment on the SEM was used to attempt to detect the inorganic elements in the erasers, present either in filmy residues or as crumbs. None of the inorganic components of the erasers were detected. However, with the high magnification imaging capabilities of the SEM the scratched lines from the diatomaceous earth were even more visible. Since it did not appear that the SEM was providing significantly more information than the binocular microscope, the remaining three samples were not coated and examined.

In one treatment at the Walters Art Gallery where eraser cleaning on marble was followed by aqueous cleaning, an increase in the water repellency of the stone, apparently as the result of the eraser cleaning, was observed. To try to get a sense of whether filmy residues from the erasers increase the water repellency of the stone, observations were made using the same tiles that had been prepared for the surface gloss tests. A 2cc syringe was used to release a single drop of distilled water on each of the three test areas, control, hand-erased and machine-erased, on the ten samples. It was not possible to measure the contact angles of the drops of water, because the drops soaked into all of the samples relatively quickly. However, differences in the rate of absorption were noted. On the polished side of the tiles, the water drops were absorbed more slowly than on the control area on all five of the machine-erased areas and on the Faber-Castell #75 and Koh-i-noor hand-erased areas. All of the rough saw-cut erased areas also had greater surface tension than the control surfaces, except for the tile treated with the Faber-Castell no. 79 white vinyl eraser, where no difference was discernible.

The erased surfaces were also examined with long-wave UV light for the presence of residues. Only the three Faber-Castell erasers fluoresce in UV light. The no. 76 soft pink eraser fluoresces yellow-orange, the no. 75 soft green eraser fluoresces a pea green color and the no. 79 white vinyl eraser fluoresces a dull orange. The no. 76 soft pink eraser left a strong directional fluorescence only on the machine-erased, saw-cut surface. The no. 79 vinyl eraser left a much fainter ghost of directional fluorescence, also on the machine-erased saw-cut area. The green eraser left no fluorescence on the stone. In both cases where fluorescence was observed on the stone it had the same color as the fluorescence of the erasers themselves.

FTIR was also used to try to detect filmy residues of the erasers on the erased marble surfaces. No components of any of the erasers were detected with FTIR on any of the test surfaces. This may be due to the strong absorbance of the marble substrate in the fingerprint region of the spectrum. The experiment was continued by machine-erasing with the erasers on highly polished black marble and mirror surfaces to see if residues could be detected on other surfaces. Once again, no residues were detected. All indications are that any residue from erasing is present in very minute quantities.

Based on the results of this study, Faber-Castell soft green and soft pink erasers are not recommended for use on marble. All of the vinyl erasers performed similarly and are acceptable for use on marble. The effectiveness of the erasers was not evaluated, but a wide range in the stiffness of the vinyl erasers was observed (Faber-Castell is the stiffest and the Koh-i-noor eraser is very flexible) and this is likely to affect the way they remove dirt. No explanation was found in our testing for the differences in flexibility and UV fluorescence of the three vinyl erasers. Because the abrasion by the soft pink and soft green erasers was only visible on the polished samples, it is recommended to test any eraser on a highly-polished sample of the type of stone to be cleaned and to test the eraser as it will be used, either hand-held or in an electric machine.

Note: As a safety precaution, dust masks should be worn when using electric erasers. To avoid accidentally bumping an object with the hard metal or plastic collets the electric machines use to secure the eraser strips, the collet can be padded by slipping a collar of thick soft tubing, such as Tygon, over it.

Acknowledgements

The authors would like to thank George Wheeler, Research Chemist,at the Metropolitan Museum of Art, for supervising FTIR and for offering guidance at many stages of the project, Dora Hanil, Research Assistant at the Metropolitan Museum of Art, for conducting all FTIR analysis, Mark Wypyski, Assistant Research Scientist at the Metropolitan Museum of Art, for conducting all SEM/EDS analyses, Lawrence Becker, Objects Conservator at the Worchester Museum of Art, for sharing with us his ideas and experience using electric erasers to clean stone.

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E. J. Pearlstein, D. Cabelli, A. King and N. Indictor. 1982. Effects of Eraser Treatment on Paper, *Journal of the American Institute for Conservation* 22(1): 1-12.

Supplier Information

Faber-Castell Corporation
41 Dickerson Street
Newark, NJ 07103
(201) 483-4646

Koh-i-noor
distributed in U.S. by:
Asbury Ferst, Inc.
3550 Zip Industrial Blvd.
Atlanta, Georgia 30354
Tel: (404) 768-8868

Staedtler, Inc.
P.O. Box 2196
Chatsworth, CA 91313
Tel: (818) 882-6000
Fax: (818) 882-3767

TABLE 1: ERASER COMPOSITION

Eraser	Manufacturer's information	EDS Results		
1) Faber-Castell #76	vulcanized rubber	Si 33%	Ti 8%	Al 1%
Soft pink for pencil	factice (vulcanized soybean oil)	Ca 19%	Ba 4%	K 1%
	calcium carbonate	S 17%	Mg 3%	Fe 1%
	diatomaceous earth	Cl 12%	Na 2%	
2) Faber-Castell #75	vulcanized rubber	Si 22%	Ba 10%	Al 1%
Soft green for pencil	factice (vulcanized soybean oil)	Ca 21%	Ti 7%	K 1%
	calcium carbonate	S 20%	Mg 2%	Fe <1%
	diatomaceous earth	Cl 15%	Na 1%	
3) Faber-Castell #79	polyvinyl chloride	Cl 64%		
White vinyl	plasticizer	Ca 30%		
	calcium carbonate	Si 5%		
		Al <1%		
4) Koh-i-noor #287	polyvinyl chloride resin dispersion	Cl 56%		
Soft white vinyl	1,2 Benzenedicarboxylic acid - 10.5%	Ca 30%		
	di (C7-11 Alkyl) esters (20.9%),	Ti 10%		
	titanium dioxide (5%)	Si <1%		
	calcium carbonate (35%)	Al <1%		
	-same as Koh-i-noor #288			
5) Staedtler #527-05	releases carbon monoxide, carbon	Cl 60%		
White vinyl	dioxide and hydrochloric acid	Ca 39%		
	on decomposition	Ti 1%		
	calcium carbonate - 34%			
	-same as Staedtler Mars Plastic 526-50			

FIELD TESTING WEBBING CLOTHES MOTH PHEROMONE TRAPS: METHODS AND RESULTS

Christine Del Re and David Mueller

A Brief History of Moth Activity and Problems in the Field Museum of Natural History

The Field Museum of Natural History has had a long history of moth infestations throughout the building . This serious and chronic problem has largely been due to the fact that in 1977, when the building was extensively re-carpeted, it was re-carpeted with a wool carpet. This carpet, which according to the Head of Facilities Planning and Operations was chosen primarily for its wear and fire-retardant characteristics, was installed mostly on the first and ground floors of the museum. Because this carpet is used so extensively, and is located throughout many public areas of the museum, i.e., hallways and galleries in addition to many offices, complete removal of the carpet - the ideal situation - would be both very expensive and very disruptive.

The alternative approach that has been taken has been to remove and replace the wool carpet with a synthetic as carpet wear, gallery renovations and other museum circumstances allow. However, this gradual program of carpet replacement has not enabled the Museum to keep ahead of the thriving moth population supported by the wool carpet.

A variety of moth infestations have been dealt with by the Conservation Division over the last 5-7 years; however, most can be attributed to that fact that although eradication and triage was done locally where and when an immediate problem was found, there still remained a resident population in the building due to the presence of the wool carpeting.

As best our collective memory serves us, problems first started in the wool carpeting in a basement corridor in the northeast section of the building a number of years ago. This corridor also happened to be very close to the Museum shop storage area, which had also had problems with moths in their textile hangings. We could never figure out if the moths came into the building via the Museum shop items, or vice versa.

In this area, that is the basement corridor in the northeast section of the building, the moth eradication procedure was to remove the carpeting, treat the area with insecticide (I was not involved with this particular problem, and do not know which chemicals were used) and put down a replacement synthetic carpeting.

Within 6-8 months of this problem, an infestation was discovered in wool textiles on exhibit in a gallery directly upstairs from this prior carpet infestation. An open stairwell separated the two areas. Since this infestation involved Anthropology Department artifacts, the Conservation Division was called in to deal with the problem. Cap Sease, the Division Head, spent some time identifying and collecting insect samples in various stages of development; then freezing and vacuuming all of the textiles. The treated textiles were then returned to the exhibition cases.

Over the past 5-6 years infestations have been found on a somewhat cyclical basis in various areas of the museum. These include:

- a recently mounted deer and fawn specimen (not treated with any chemicals during mounting)
- Bolivian textiles in the Collections of the Education Department;
- the wool carpeting throughout the entire Education Department offices;
- the wool carpeting in an old exhibition hall that had been converted to a storage room for the Housekeeping Department, known as Hall J;
- the wool carpeting and dried fish specimens in one of the Fish Storage areas;
- the Harris Extension School Loan offices, workrooms and loan boxes;
- an ethnographic loom strung with cotton fibers, but with wool fibers holding the vertical members of the reed.

Rationale and Procedures for Testing the Pheromone Traps at the FMNH

In the Spring of 1992, the Anthropology Department of the FMNH attempted an anoxic CO_2 purge of one of its ground floor storerooms to kill a suspected moth infestation. This attempted purge was done by a company named Fumigation Services and Supply based in Indianapolis. In conversations with John Mueller of Fumigation Services and Supply, who knew the history of moth problems at the FMNH, I discovered that Dave Mueller of Insects, Ltd., also in Indianapolis, was developing a pheromone trap for the ubiquitous Webbing Clothes Moth. I told John Mueller that as soon as such a pheromone trap was developed, I would be interested in purchasing them for the Museum.

The Development of the Webbing Clothes Moth Pheromone Traps

Dave Mueller of Insects, Ltd. in Indianapolis, Indiana, did the research and development for the Webbing Clothes Moth pheromone trap. Gas chromatography done by an independent analytical lab in Japan revealed the pheromone to be composed of two parts: an active and an inactive part. However, the qualitative pheromone analysis did not reveal the ratio at which these two parts are present in the pheromone.

Therefore, the initial traps that were designed for testing by Insects, Ltd. were made of varying ratios of the two component parts of the pheromone. Two types of pheromone mixes were initially developed: a 2:1 active to inactive component mix; and a 4:1 active to inactive component mix.

After detailed discussions with Dave Mueller, I volunteered the FMNH as a field testing station for the pheromone traps to help him determine which of the various ratios of the pheromone mixes was more effective. Given the history of moth infestations in the museum, and its thriving moth population, the FMNH seemed like an ideal test site.

Objectives of the Program

The trapping program was set up to help us determine:

- the best ratio between the two components in the pheromone trap;
- Whether any previous eradication methods, such as the Dursban treatment of the carpeting in the Education staff offices, had been effective;
- where exactly the moths were, in what quantity, and whether the populations were stabilizing, increasing or diminishing.

Design, Location and Spacing of Traps

Eight areas of the building were set up with Webbing Clothes Moth pheromone traps:

- the Harris School Loan offices
- the Education Department
- the War Room (the Security staff's break and lunch room)
- Hall J
- Classroom 3
- the Webber Resource Center
- Fishes
- the southwestern Loom

All of these areas had previously been known to have had a moth infestation.

The traps were hung with pieces of plastic coated twisted wire at about eye level, which is the optimum flying height of the moths. They were placed roughly about 20 feet apart. (The traps draw from a 20-25 ft. radius.) Webbing clothes moths tend to stay close to their feeding sites and seldom fly for very long distances. Also, it is important to note that the higher the temperature and the relative humidity, the more active the moths. A reduction of RH below 70% will slow both reproduction and feeding. There is generally a spring hatching, from around mid-March onwards in my experience, and a Fall hatching, although the Fall population is generally lower.

Control traps were also hung in all testing areas in a ratio of 8 baited to 1 unbaited, to help determine the real effectiveness of the traps. A few other kinds of sticky traps were also tested at the request of other colleagues.

Preliminary Results

The use of the Webbing Clothes Moth pheromone traps at the FMNH was one of the most successful preventive conservation measures I have ever been involved with. We were able to achieve all of the goals that we had set, and obtained concrete evidence about the effectiveness of the various pheromone mixes.

The 2:1 pheromone trap was approximately <u>four</u> times more effective at catching moths than the 4:1 pheromone mix.

We found that the residual chemical treatment of the carpet in the Education Department offices had been highly effective: the area stayed moth free for at least one year following treatment.

The traps also allowed us to locate many areas of serious moth infestation where we never would have thought to look.

One of the most interesting challenges for all of us involved in this trap monitoring program was learning to use the traps to locate the locus of a moth infestation based on the number of moths that were present in the traps. There would be moths in a trap, and the count would go up week after week, but sometimes it proved to be very difficult to actually locate the infestation itself. In one case, everything in the 20-25' radius was dismantled before the source of the infestation was located. This particular batch of moths were in a box of polyurethane foam. Because there were no traditional food materials in the foam box (which was directly under the trap), it was not originally examined. We learned from this that the moths will cocoon almost anywhere, and in anything.

Steps Taken to Reduce Moth Problems

This moth monitoring program allowed us to develop and take many steps to control and eradicate the moths throughout the ground and first floor areas of building. These steps were based on the concrete evidence of the moth populations found in the traps, and included the following:

Museum-wide:

- continued gradual removal of wool carpeting in non-public areas

Education Dept:

- removal of all infested materials
- spraying the entire area and carpet with a knock-down pyrethrum, and the carpeting with Dursban (a residual insecticide).

Harris School Loan Office:

- removal of wool carpeting from all non-public areas
- isolating the Education boxes with plastic bags
- purchase and use of freezer
- regular and careful inspection of all items that return from outside loans

Loom:

- disassembly, cleaning and freezing of the reed

Acknowledgements

As always, the success of a big project such as this is dependent on the support and co-operation of many people. Without the continual backing and support of the Head of Facilities Planning and Operations, very little headway could have been made with the removal of the carpet from its multiple locations in the building. Dedicated trap monitoring was carried out by Collections Managers, and members of the Education and Harris Extension offices.

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A PRELIMINARY REPORT ON CONSERVATION RESEARCH INTO THE RURAL ART PARKS OF WISCONSIN

Anton Rajer, Dr. Harry Alden and Dr. John Hackney

Our ongoing research aims to study the factors effecting the deterioration of 20th century outdoor mixed media sculpture in the upper Midwest and to help develop strategies for their preservation. Many of the sculptures are located at sites known as "art parks" or outdoor sculpture gardens. Eight of these art parks are located in the state of Wisconsin. Created by self-taught artists commonly referred to as "outsiders" or "primitives," the art parks evolved over a sixty year period between 1920 and 1980.

1. Grotto of the holy Ghost, Dickeyville
2. Nick Engelbert, Hollandale
3. Wisconsin Concrete Park, Philips
4. Grotto Gardens, Rudolf
5. Prairie Moon, Cohrane
6. Wegner Grotto, Cataract
7. Mary Nohl, Fox Point
8. James Tellen, Sheboygan

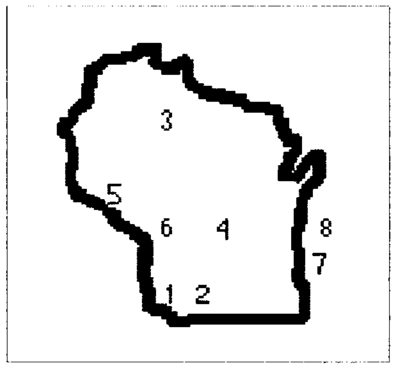

Figure 1. Wisconsin's Art Parks

The preferred materials of the spontaneous constructions of these rural visionaries included wood, concrete, glass, metal, plastic, and stone. Working in apparent isolation, the artists relied upon an inner vision and inspiration from religious, civil, and historical events to guide them in their creative endeavors.

Preservation efforts at all the sites have been hampered by a harsh climate marked by frigid, snowy winters and sweltering, humid summers. Biological growth, including lichen and moss, plague many of the sculptures. In addition, the remote rural locations of many of the sites and the unusual construction materials often utilized by the artists have made site work difficult, requiring preventive conservation strategies tied to economic reality. Our research project has focused on biological, chemical, and physical components in the degradation and biodeterioration of these sculptures.

The primary focus of our research has been the Wisconsin Concrete Park, created by Fred Smith (1886-1976), which consists of well over 200 life-sized concrete figures which surround his rural home and tavern near Philips, Wisconsin. The site became a county park after a restoration in 1977.

Utilizing the ICCROM model for a work of art within its outdoor environment, we are studying the factors affecting the objects. Lichen, fungus, moss, and wood has been identified in order to understand the mechanisms of biological and physico-chemical degradation effecting the pieces. Figure 2 provides a graphic representation of the theory behind our research.

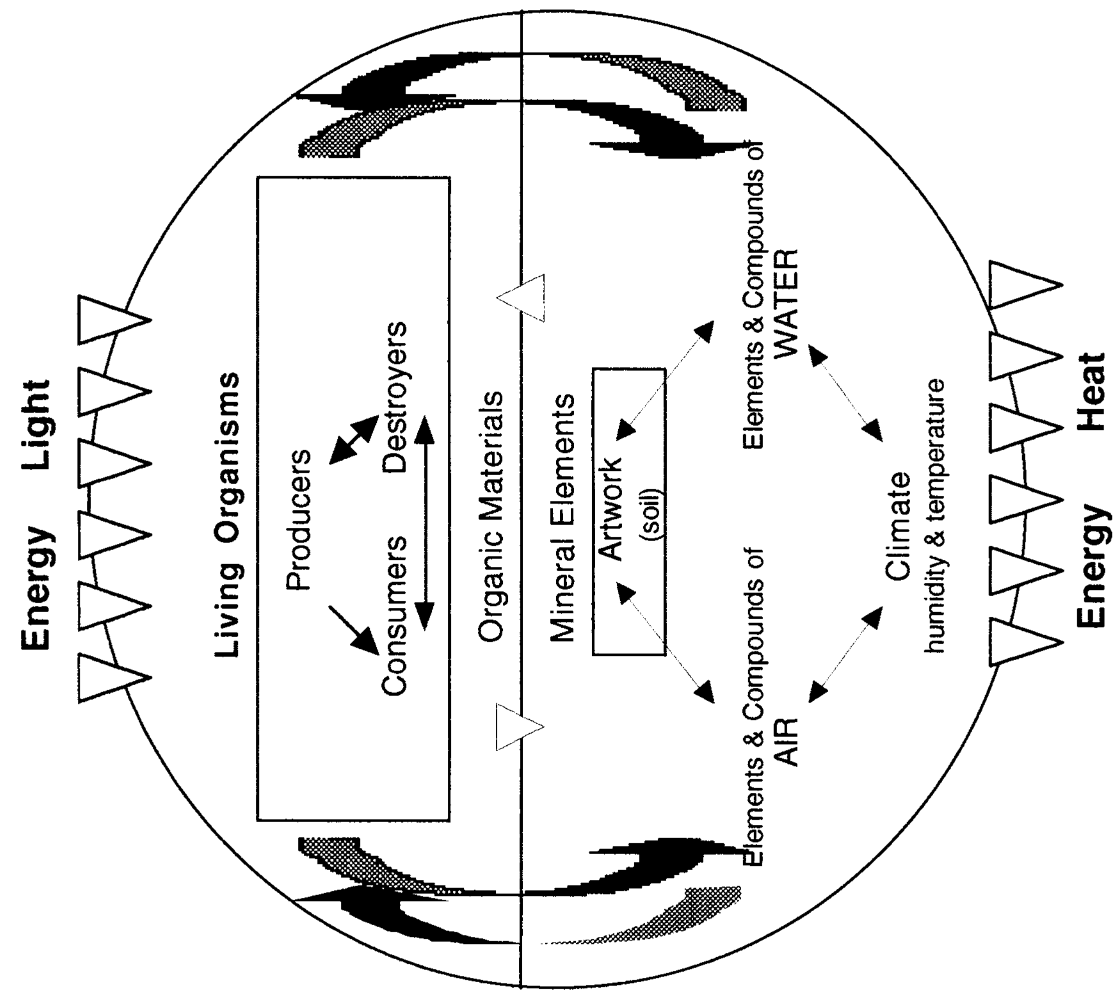

Figure 2. ICCROM Conceptual Model

In addition, climate studies have indicated periods of high wind sheer, sub-zero freezing, and dramatic fluctuations in temperature through the day and the year. Future research will focus on the identification of mortar and metallic corrosion, and on creating models for potential sculpture stabilization. Working with the Friends of Fred Smith Association, some preventive conservation procedures have included the planting of native prairie grasses near the sculptures to prevent touching by the public, inventorying glass shards from the sculptures, covering some of the statues in the winter, and improved written records on each piece. Routine maintenance and periodic controls are sometimes the only way to prevent biological attack in an outdoor environment. (See Tables 1 and 2, Figures 3 and 4).

Two sites which have been particularly well-maintained have benefited from their association with the Catholic Church. The Grotto of the Holy Ghost, in Dickeyville, was begun by Father Wenerus around 1919. Composed of concrete and other materials, the grotto contains a shrine devoted to the Blessed Virgin, the Sacred Heart, and Patriotism. An equally important site, which also served as the inspiration for other art parks, is the Rudolph Grotto in Rudolph, Wisconsin. The site is notable for its use of a local dark red stone and white marble sculpture. Regular maintenance efforts are carried out at both sites, including lichen removal, landscape maintenance, sculpture upkeep, and general care. As expected from the ICCROM model, the efforts made at these sites have succeeded in reducing biological and physico-chemical degradation, in spite of a harsh climate.

Another art park is in Hollandale, where Nick Engelbert (1881-1962) created over two dozen pieces of sculpture which reflect his interest in American culture. Unfortunately, the site has been abandoned for the past twenty-five years and many of the sculptures have been lost. However, much of interest remains and warrants preservation, particularly the original polychrome surface of many of Engelbert's pieces. Unfortunately, the current private owner intends to repaint the sculptures in 1995 as part of a sprucing up project.

In contrast to the Hollandale site, the Wegner Grotto has an on-going maintenance program. Located near Sparta, the art park contains in excess of three dozen pieces by the Wegners, a self-taught couple. The site reflects the strong influence of the Grotto at Dickeyville, which the Wegners observed on a family outing. The Wegners constructed a series of decorative fences, sculptures, and a small church made mostly of concrete. Runoff from rain water, a nearby highway, moss and lichen growth, and debris from extensive foliage have all caused problems at the site. The site was restored in 1987 and has since become a county park; fortunately, the Wegner's great grandson maintains the site and lives nearby.

Ironically, the beautiful setting of the Mary Nohl site, on the shore of Lake Michigan in the Milwaukee suburb of Fox Point, has proven problematic to its preservation. The artist, who still lives in the house at the site, has created incredible tableaux both within the house and its surrounding yard. Unfortunately, high incidence of vandalism have moved Nohl to construct a high, barbed wire fence around the site. The sculptures are also subject to the brutal force of winter winds coming directly off the lake. Though generally well maintained, the future of the site remains uncertain.

Research into the materials and techniques used in the construction of the art parks and their deterioration continues and we are in contact with colleagues working at the Watts Towers in Los Angeles and various rural parks including the Garden of Eden in Kansas and the Paradise Garden in Sommerville, Georgia. Ongoing research at the University of Wisconsin and Forest Products Laboratory continues to explore the physical composition of the sculptures and the ways in which their materials behave in the outdoor environment. Finally, SOS! (Save Outdoor Sculpture) has played an integral role in heightening public awareness of the importance of saving Wisconsin's rural art parks. Developing strategies to conserve these eccentric sculptures has been a perplexing challenge; a challenge worthy of continued efforts.

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The Sites	Materials	Concrete	Glass	Stone	Shells	Ceramics	Plastic	Metal	Paint	Wood	Biological growth	Plastimatia Glauca	Xanthoria Fallax, Spec.
Mary Nohl		X						X	X	X			
Engelbert Site		X	X	X	X	X		X	X	X			
James Tellen		X		X				X	X			X	X
Praire Moon		X	X	X	X	X		X	X	X			
Wegner Grotto		X	X	X	X	X		X	X			X	
Rudolph Grotto		X	X	X	X	X		X	X				
Dickeyville Grotto		X	X	X	X	X		X	X				
Concrete Park		X	X	X	X	X	X	X	X	X		X	X

Table 1. Site Materials and Biological Growth.

The Sites	Temperature--Lowest	Temperature--Highest	Average relative humidity %	Precipitation per year	Rainfall--average	Snowfall--average	Ph, precipitation by weighted means
Mary Nohl	*	*	*		*	*	*
Engelbert Site	-37F	104F	72.7		30.8"	42.7"	
James Tellen	-26F	107F	73.2		31"	47"	4.6 *
Praire Moon	-37F	105F	71.5		30.5"	42.4"	5
Wegner Grotto	-37F	105F	71.5		30.5"	42.4"	
Rudolph Grotto	*	*	*		*	*	4.9 *
Dickeyville Grotto	*	*	*		*	*	4.8
Concrete Park	-40F	98F	*		30.5"	37.7"	4.8

Stastics courtesy of U.S. Weather Bureau
* Research in progress

Table 2. Site Climatology.

Figure 3. Wisconsin Concrete Park. Wooden braces support a weakening sculpture.

Figure 4. Wisconsin Concrete Park. Corroding iron armature has led to the deterioration of the concrete veneer.