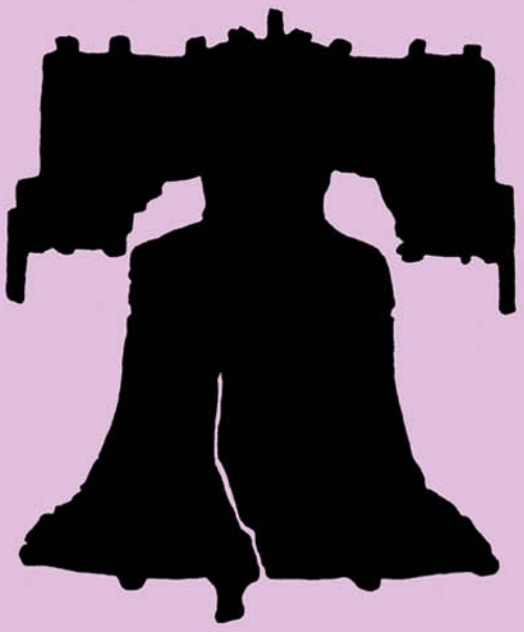
Objects Specialty Group Postprints

Volume Seven

2000



American Institute for Conservation of
Historic and Artistic Works

Objects Specialty Group Postprints

Volume Seven

2000

Compiled by Virginia Greene and Jessica S. Johnson

Proceedings of the Objects Specialty Group Session
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FOREWORD

This is the seventh volume of the *Postprints* published by the Objects Specialty Group (OSG) of the American Institute for Conservation of Historic and Artistic (AIC). It contains eight papers from the OSG session of the June 2000 AIC annual meeting held in Philadelphia, Pennsylvania. It also contains one paper presented in the General Session. One abstract has also been included for a paper that has been published on the World Wide Web.

The title of the session was "Interchange: Replicas, Research and Resolution", a rather clumsy attempt to find a few words that sum up how conservation is very consciously working at finding ways to translate our passion for preserving cultural and natural heritage into a form that others can understand and accept. Sometimes that "translation" is conscious like the National Park Service *Exhibit Conservation Guidelines* CD-Rom. Sometimes it is using our techical skills to replicate all or part of an object for research questions or exhibit needs. Sometimes it is making preservation part of the use of an object so that public can understand in a very immediate way how people lived and worked with objects. What was illustrated over and over again, was how all these projects worked because conservators were able to adapt and work with other perspectives to incorporate conservation into larger projects.

The papers in this volume were edited minimally, but they were not peer-reviewed and authors are encouraged to submit their papers to juried publications such as the *Journal of the American Institute for Conservation*. Authors retain all rights of reproduction of the text and images. Four papers from the session are not included here. We hope the authors will submit them for publication in another venue as well.

A special thanks goes to Virginia Greene, who has been responsible for editing OSG Postprints since 1995. They would not exist without her good work.

CONSISTENCY OF STRUCTURE: THE CONSERVATION OF CHARLES & RAY EAMES "STUDY FOR A GLIDER NOSE"

Roger Griffith

Abstract

(The full version of this paper can be found on the MOMA website: http://www.moma.org/collection/conservation/)

The 1943 design and construction of the 'blister' for "Study for a Glider Nose" by Charles and Ray Eames represents an important and innovative contribution to the development of the single-shell molded plywood chair. Charles & Ray Eames spent from 1940-1945 perfecting the fabrication of molded plywood with compound curves. Through their home experiments and commissions from the US Navy they began by designing molded plywood leg splints for medical use. The splints were a success and other products they designed included a molded plywood body litter and an arm splint. The litter and arm splint, however, were never mass-produced. When the Eameses set out to construct a one-piece wooden section as large as the 'blister' it was regarded as a nearly impossible task.

In 1943 the glider designer Hawley Bowlus of Airborne Transport, Inc. asked Charles & Ray Eames to assist in the experimental design of a glider, the CG-16 "Flying Flatcar". The glider was to be used for transportation of military equipment and personnel. One prototype glider was built, and the Molded Plywood Division of Evans Products was contracted to produce part of the nose section and the fuselage formed out of plywood compound curved body units.

The emphasis on control and accuracy in the production of wartime products had a positive effect on the design and construction of later plywood products by the Eameses. The naval commissions also meant that priority materials such as synthetic adhesives were made available to the Eameses that otherwise would have been impossible for them to obtain. These materials were essential in the development of their postwar ventures into mass-produced plywood objects. The goal the Eameses set for themselves was a technique for mass-producing curved plywood shapes that could be used to make low-cost, high-quality furniture. Although the Eameses were not ultimately successful in producing a single-shell chair molded in plywood, their eventual chair designs such as the DCW (Dining Chair Wood) and the DCM (Dining Chair Metal, sometimes referred to as the *potato-chip chair*) are considered by many to be the most important chair designs of Post-War America.

This paper examines the design and construction of the " Study for a Glider Nose" as well as the use of various materials and industrial technology developed during the war. Recent conservation treatment and examination of the "Glider Nose", performed at the conservation laboratory at The Museum of Modern Art, revealed the Eameses unique construction techniques and their ultimate

success of bending plywood into compound curves. Scientific examination such as adhesive analysis was helpful in determining the actual construction of the "Study for a Glider Nose" providing heretofore non-existent documentation.

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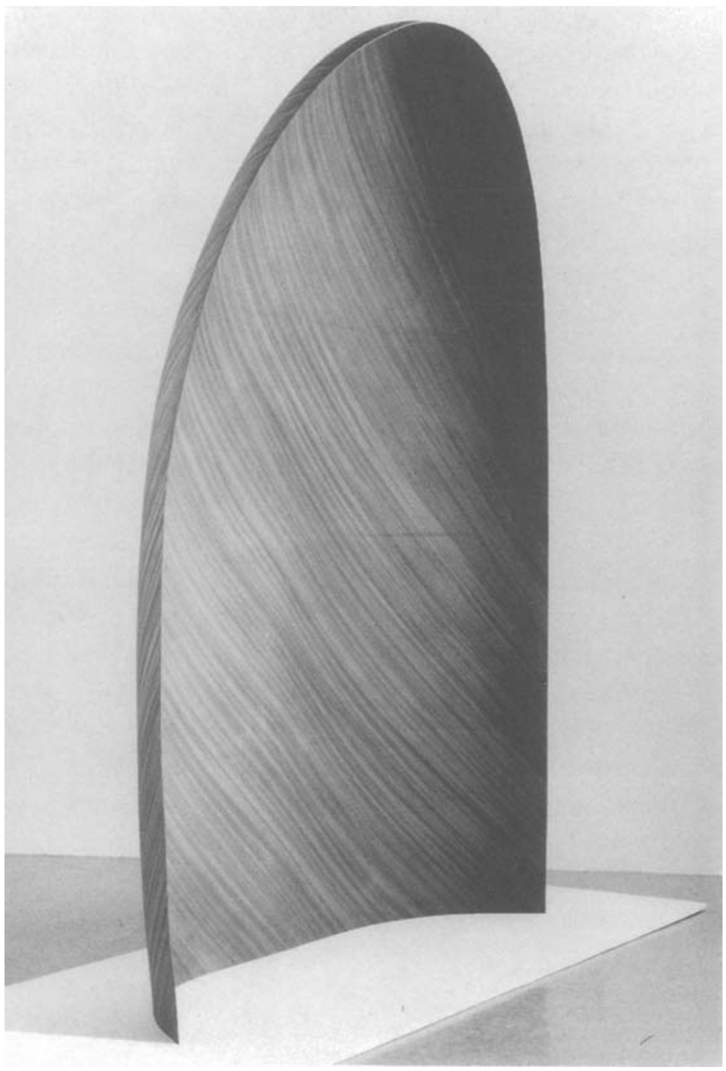


Figure 1. Charles and Ray Eames. "Study for a Glider Nose" (1943). Molded Birch Plywood with Mahogany Veneer. 10'5 ½" x 6' 8" x 31 ½" (318 x 203 x 80 cm). Collection, The Museum of Modern Art, New York (103.89). Gift of Lucia Eames Demetrios. Photograph by Roger Griffith.

A SET OF CONSERVATION GUIDELINES FOR EXHIBITIONS

Toby Raphael and Martin Burke

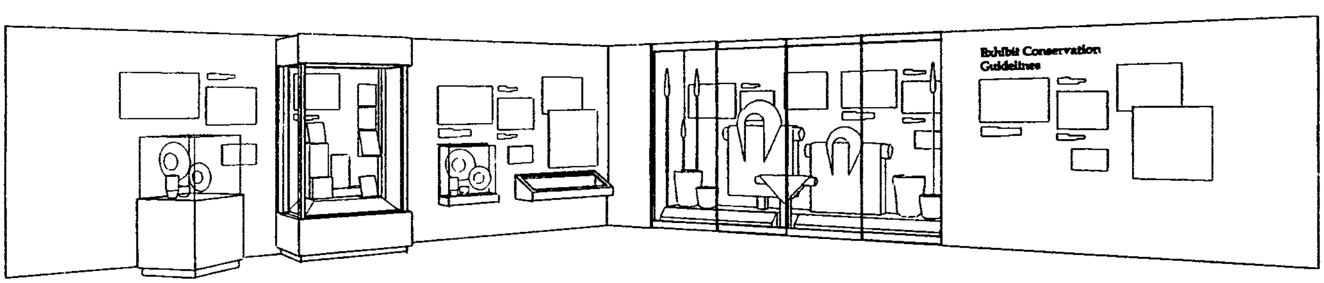
Exhibit conservation focuses on practical techniques that protect museum collections from unnecessary damage while on display. The National Park Service has recently completed a technical resource intended to assist exhibit specialists achieve preservation-responsible exhibits. The document is called the Exhibit Conservation Guidelines and has been produced as an electronic publication, presented in a CD-ROM format. Exeprts are included below.

Improperly designed and poorly fabricated exhibits are a significant source of damage for museum collections. Several years ago the Department of Conservation embarked on a major preventive conservation project to develop a set of practical, exhibit guidelines. The objective was to create a "user friendly" technical resource for both NPS personnel and exhibit specialists in general.

The *Exhibit Conservation Guidelines* establishes a methodical approach for the inclusion of conservation in the often-confusing processes of exhibit development and production. It defines the critical areas of involvement for conservation specialists, includes the baseline information known in the field and adds what we at the NPS have learned from many years of producing exhibits.

Only by involving conservation early and throughout the process, can we ensure preservation-responsible planning, design and production. Years of experience have taught us that successful exhibits require a close, constructive working relationship between exhibit, curatorial and conservation specialists. A sense of shared responsibility for collection preservation and trust are invaluable parts of the equation.

The technical resource includes over 300 pages of guidelines, technical notes and drawings. Information on obtaining the *Guidelines* may be obtained through the National Park Service's exhibit web page: www.nps.gov/hfc/conservation/exhibit. The following is a summary of the narrative section of the *Guidelines*.



A. Exhibit Planning

A.1 Integrating Conservation into the Exhibit Process

✓ Integrate conservation early in the exhibit planning phase. Make a commitment to preserving objects placed on exhibit by including conservation concerns throughout the development and production of the exhibit.

✓ Provide adequate time and resources. Build in enough time for development and review of technical designs, case prototypes, lighting mockups, and the testing of proposed materials. The schedule must allow for safe handling, exhibit mount making, and installation of objects. Include the costs of addressing preservation issues, such as treatment and special casework, in the budget.

✓ Search for balanced conservation solutions. Employ solutions that are appropriate for the specific exhibit circumstances and balance conservation criteria with other exhibit requirements.

A.2 The Exhibit Team

✓ Work cooperatively. Each team member should take responsibility for understanding basic conservation issues and working with other members to achieve preservation-responsible displays. The search for balanced and appropriate solutions often requires compromise.

✓ Hire supportive design staff. Use designers who are experienced in working with exhibit conservators and firms that have a history of producing preservation-responsible exhibits.

✓ Demand high construction standards. Develop drawings and specifications that clearly articulate the intended conservation features; consider including performance criteria. Oversee production contractors to ensure that conservation components are built as specified.

A.3 The Role of the Exhibit Conservator

✓ Include an exhibit conservator on the exhibit team. Select a conservator who is qualified in the specialty of exhibit conservation. Often, a part-time consultant is sufficient.

✓ Involve the exhibit conservator in the earliest stages and throughout the exhibit planning, design, fabrication, and installation process. An exhibit conservator should set conservation criteria, participate in planning and design meetings, review conservation-related decisions, and assess prototypes and exhibit work after installation.

A.4 Selecting Objects

✓ Select appropriate display objects. Make the selection in conjunction with a conservator who can establish whether the objects are stable enough to exhibit (with or without treatment) and the ramifications of exhibiting them.

✓ Avoid selecting too many objects. Review the number of objects that can be accommodated safely within the available space.

✓ Consider the aesthetics of each object. Object selection should include curatorial review of the visual message presented. Incomplete, deteriorated, or dirty objects may require extensive treatment.

✓ Avoid permanent exhibit of objects. Consider rotating vulnerable objects, substituting alternate objects, or using reproductions. When possible, use a reproduction to demonstrate the function of an object.

✓ Allow enough time and resources to safely prepare, mount, install, or replicate exhibit objects.

A.5 Establishing Conservation Criteria

✓ Review the objects. Examine each object chosen for display to determine its current condition and individualize its conservation requirements. Complete a written condition assessment of the objects.

✓ Establish necessary but realistic conservation criteria. Base the requirements on an assessment of the individual objects, the likely environment in the exhibit space, and current conservation research.

✓ Address the conservation criteria. Incorporate the conservation recommendations into the exhibit design. The designer, conservator, curator, and other team members must work cooperatively to ensure practical display methods that preserve the objects.

A.6 Collections Management

✓ Ensure safe handling. Provide training for anyone who handles an object during the exhibit process. Dedicate a clean, secure space for temporary storage of objects during exhibit development, construction, and installation.

✓ Stabilize all objects. Have a conservator document their condition and provide a treatment proposal for those that require treatment. Secure the necessary funding for treating unstable objects before display.

✓ Document objects. An exhibit object list should include the accession or catalogue number of each object. Photographs of the objects and floor plans marked with object location facilitate security and condition checks.

✓ Protect objects during photography. Limit an object's total exposure to light, and avoid overheating objects with studio lights. Use a flash system, especially for light-sensitive objects. Always provide appropriate support for objects.

B. General Design

B.1 Multilevel Conservation Response

✓ Design for environmental stability and protection. Choose an appropriate and efficient response from among the multiple options available. Consider what level of protection is obtainable and what kinds of tradeoffs each will impose on the conservation criteria.

✓ Consider both macro and micro approaches. Weigh the benefits and costs of addressing conservation criteria throughout the exhibition against creating microenvironmental solutions using exhibit cases.

B.2 Exhibit Format and Layout

✓ Use enclosed display when possible. Avoid open display except in historic house museums and some gallery settings or when an object's size makes enclosure impractical. Open display should never be a routine exhibition option or one chosen solely for financial reasons.

✓ Allow sufficient room for traffic flow. Design the exhibit to avoid accidents. Provide adequate space through the exhibit and around exhibit cases for the easy movement of individuals, groups, and people in wheelchairs.

✓ Group similar objects. Consolidating the location of collections with similar conservation criteria will make it easier and more economical to meet the design goals. Consider ease of installation, maintenance and object removal.

B.3 Temperature and Relative Humidity

✓ Know the environment. Monitor an exhibit space for one year to obtain baseline information about the temperature and relative humidity. Review these environmental data for each exhibit to determine if existing conditions meet the conservation criteria.

✓ Control the environment within the entire exhibit space. In general, keep temperature between 60 and 70° F (15.5 and 21° C) and relative humidity between 40 and 60%, eliminating rapid cycling of temperature and relative humidity. Requirements for special objects and certain geographical areas may vary.

✓ Locate sensitive objects in the most stable locations. Do not place moisture-sensitive collections in the path of direct sunlight, near heating or air-conducting ducts, against external walls, or in damp locations such as basements. Avoid putting cases and framed works along exterior walls.

✓ Provide additional control for sensitive objects. Use sealed cases where appropriate to slow air exchange and thus stabilize environments inside cases. When called for, create a microclimate by incorporating silica gel or other climate control products within cases that contain moisture-sensitive materials.

B.4 Particulate Contamination

✓ Enclose sensitive objects. Incorporate air filters in ventilated case designs or seal exhibit enclosures sufficiently to prevent particulate entry.

✓ Use high-efficiency filters in environmental systems for rooms housing exhibits. HVAC filters should remove particles down to 1-0.3 microns (60-80%). Change filters regularly.

✓ Use localized filtration equipment. If improving filtration throughout the museum is not feasible, consider using room-sized units in construction areas or within the exhibit space.

B.5 Chemical Pollutants

✓ Monitor pollutants. Assess the air quality within the museum to establish the ambient level of contaminates. This knowledge will point to the measures necessary to meet the conservation criteria for an exhibit.

✓ Incorporate chemical filters in the environmental systems. For susceptible collections or in highly polluted locations, include activated charcoal or potassium permanganate filters in the environmental system.

✓ Provide air circulation. Adequate air circulation will lower total pollutant concentrations; high rates of airflow over or near objects, however, increases their exposure. Design the exhibit layout to minimize the objects' exposure to pollutants.

✓ Select stable construction materials. Avoid materials known to emit hazardous materials, become acidic, or lose their physical or chemical stability with age.

✓ Aerate the exhibition space before object installation. Allow time for initial levels of outgassing from new materials to dissipate.

✓ Enclose sensitive collections. Cases that incorporate a chemical pollutant scavenger provide a high level of protection for sensitive objects.

B.6 Exhibit Lighting

✓ Develop a lighting plan that responds to the established conservation criteria. Produce the plan early in the process to allow enough time for coordination of the complex issues that determine final lighting choices and levels.

✓ Limit total light exposure. Provide separate lighting for security checks, exhibit cleaning and maintenance, object installation, and other routine work. Turn off lights during nonpublic hours so as not to expose objects to light unnecessarily. When possible, use occupancy sensors in the room or at the case to turn lighting on and off during visitation hours.

✓ Filter all sources of ultraviolet radiation. Use commercially available filters on all light sources to reduce the levels of ultraviolet radiation to 10 microwatts per lumen.

✓ Control infrared radiation. Locate objects at least 24 inches from fluorescent lights and at least 36 inches from incandescent or tungsten halogen lights.

✓ Exclude sunlight. Design exhibit spaces to prevent daylight from reaching display objects. Daylight already present in the exhibit space should be filtered for UV radiation and lowered in intensity.

✓ Construct lighting mockups to evaluate the amount and quality of light provided by the proposed lighting plan. Measure final light levels and adjust them accordingly during installation.

B.7 Biological Infestation

✓ Examine objects for signs of infestation and active mold as part of the preliminary condition check. If signs of infestation are found, consult a conservator about treatment options.

✓ Design exhibits to inhibit infestations. Make sure the exhibit area is insect-proof by screening open windows or doors, filling gaps in the building construction, and avoiding gaps and undercuts where dust can collect.

✓ Enclose objects. When the risk of infestation is high, place susceptible objects inside well-sealed cases or sealed acrylic boxes to prevent new infestation. Limit the gaps and holes to prevent insect entry.

✓ Avoid introducing insects through props and unchecked exhibit materials. Do not use wool carpets and other materials that attract and harbor insects. Avoid using organic exhibit props. Fumigate any organic props or expose them to freezing temperatures before bringing them into the museum.

✓ Control human behaviors that encourage infestation. During exhibit production and installation and after the exhibit opens, never allow food in the object holding areas or the exhibit space, even if no objects are in the area.

B.8 Physical Security

✓ Conduct a risk assessment. Identify the likelihood of theft and vandalism. Provide protection against human damage. Exhibits in a museum with a history of vandalism and theft may require additional security measures.

✓ Provide the appropriate level of protection. Tailor security features to the vulnerability of the objects. Highly vulnerable and valuable objects require more sophisticated protection measures than others.

✓ Use tamper resistant hardware. Mount objects to panels or shelves, bolt freestanding cases to the floor, and lock exhibit cases.

✓ Facilitate authorized curatorial access to the objects. Each object in an exhibit should be readily removable without having to remove or disturb adjacent objects.

B.9 Emergency Preparedness and Fire Protection

✓ Develop fire protection and emergency response plans. The museum staff should have an emergency plan for each exhibit space. The plans should minimize threats to museum objects, protecting them during a disaster, during their evacuation, and after a disaster.

✓ Perform a risk assessment and address potential problems. Anticipate the types of damage that may occur to display objects. For example, avoid placing objects, especially if they are water sensitive, in the path of fire sprinkler heads.

C. Exhibit Case Design

C.1 Designing a Conservation-Grade Case

✓ Design cases as protective enclosures. Take advantage of a well-designed case to control the microenvironment of sensitive collections. A case designed with the participation of an exhibit conservator is an efficient and often cost-effective way to meet conservation criteria for an object.

✓ Establish performance criteria. Determine what conservation features will be built into each case, and clearly identify performance criteria for each feature. Design the case to provide this performance.

✓ When possible, build and test a prototype case to decide whether it meets design objectives. Modify the case until acceptable performance is achieved.

✓ Provide detailed, explicit drawings and specifications. Inspect cases during fabrication to ensure that the fabricators stick to specifications and construction tolerances.

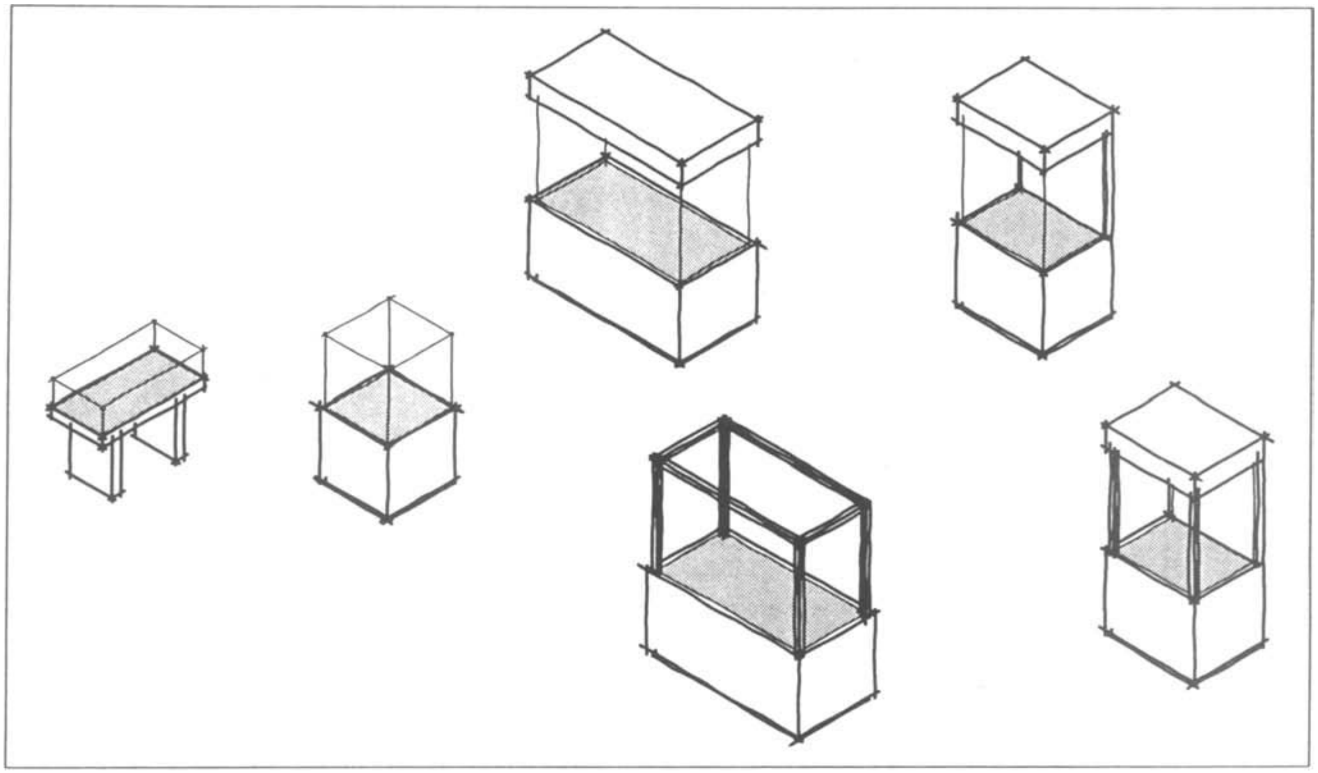
✓ Test the fully assembled case in its final location to ensure that conservation criteria have been met. Such testing should occur before object installation to allow for adjustments.

C.2 Case Stability, Security, and Access

✓ Construct a physically stable, structurally secure case. Limit vibration by using movement dampening devices. When floor or wall attachment is not possible, include space for a weight ballast to prevent jarring and tipping.

✓ Provide appropriate security features. Choose from security options to include the level of protection that the design team considers prudent. The case strength, resistance, and security devices should match the projected threat from vandalism and theft.

✓ Provide for legitimate access. Incorporate doors or other practical access options in the case design. Ensure that a single person can enter the case and remove artifacts with ease and in a short amount of time.



C.3 Sealed Exhibit Cases

✓ Use sealed display cases when appropriate. Determine which objects, if any, require protective microenvironments, and design cases accordingly. Design cases to avoid the risks presented from interior contaminates and from condensation due to exterior temperature change.

✓ Design well-sealed cases with tight joints and with gaskets around all removable panels and entry doors. Choose construction materials that limit air exchange and, for climate-controlled case designs, are not moisture-permeable. Well-sealed cases should allow no more than one complete air exchange every 72 hours.

✓ Use conservation-appropriate sealants. Minimize leaks with adequate gaskets and caulk. Always choose non-hazardous materials.

✓ Test case performance. When possible, use leak detection equipment to identify air leaks and determine air exchange rates. Modify the case design or add caulk and gaskets to reduce leakage.

C.4 Ventilated Exhibit Cases

✓ Use ventilated cases for appropriate applications. Select vented cases for use in an exhibit space with a good climate-control and pollutant-control system that functions 24 hours a day.

✓ Control the design and construction of ventilated cases. Design well-sealed cases, and place an adequate number of vents to provide for air movement. Filter the vents to prevent dust, insects, and chemical pollutants from being drawn into the case.

✓ Use positive-pressure cases when appropriate. Museums with good climate-control systems may be able to use these cases, which are practical and economical to build because they do not have to be well-sealed.

C.5 Lighting Design within Cases

✓ Develop a case lighting plan and specify appropriate lighting equipment. Address lighting issues early as part of technical plan which identifies the best suited light source, fixtures, lamps, light modifying and heat reducing equipment.

✓ Isolate lights from the display chamber. Place all lighting fixtures outside the display area of a case. Contain any lights that are integral to the case in a separate compartment. Seal off the lighting chamber to prevent the entry of insects, heat, and dust into the display chamber.

✓ Reduce heat gain and temperature cycling. Ventilate the lighting chamber to dissipate heat from fixtures and lamps. In larger cases or cases located in enclosed spaces, electric fans may be required. Heat gain inside the display chamber should be no more than 2° F when lights are turned on.

✓ Incorporate heat-reflecting and insulating materials when necessary. Consider heat-reflecting glass or double-glazed construction for panels that separate the lighting and display chambers. To help prevent heat buildup, insulate lighting compartments below the display area and use a non-insulating material such as metal products to construct light attic chambers.

C.6 Humidity-Control Principles

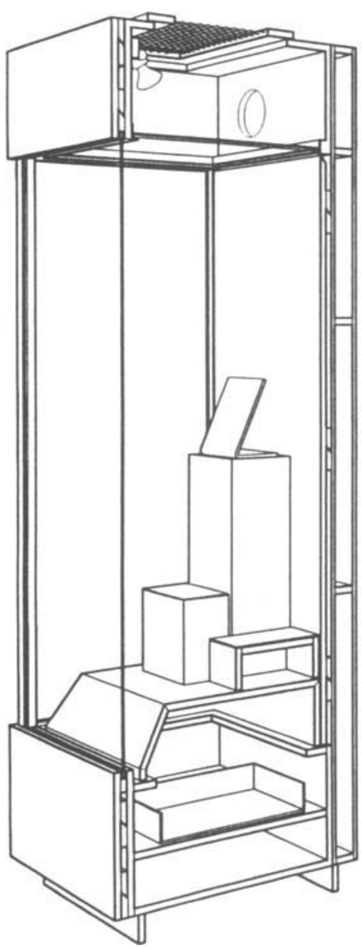
✓ Provide a well-sealed case that will support humidity control. Minimize the air exchange between the case and the room. To no more than 1 air exchange per 72 hours. Use moisture impermeable construction materials.

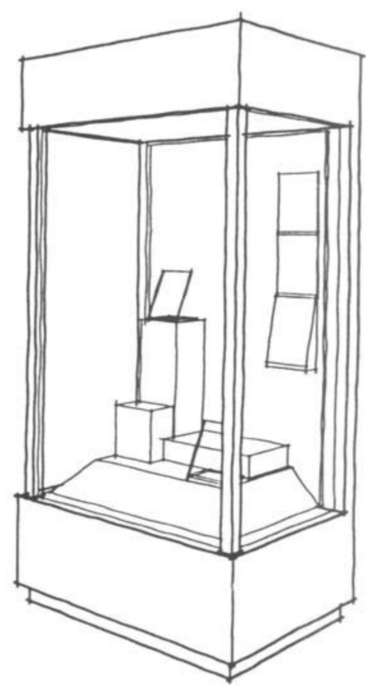
✓ Ensure adequate air circulation within the case. If the environmental maintenance chamber is located beneath the objects use a perforated deck or a floating deck with a sufficient perimeter gap to avoid impeding the air from circulating throughout the display.

✓ Provide separate access to the environmental maintenance chamber. Access panels to the environmental controlling equipment should be as small as feasible and tightly sealed with gasket materials. Large cases may require numerous points of access.

✓ Test the case before enclosing objects. Ensure that the humidity inside the case meets the conservation criteria, even when exterior conditions are at projected extremes.

✓ Monitor the interior relative humidity for the duration of the exhibit. If identical cases are used, systematic sampling may be adequate.





C.7 Active and Passive Humidity-Control

✓ Establish whether the goal is stabilization or control. Stabilizing the humidity inside a case is usually sufficient unless objects require a highly restrictive or specific RH range.

✓ Select an appropriate method. Use mechanical systems cautiously, and choose specific equipment carefully. When using a passive system, design the case to include a holding area for the moisture-absorber medium with easy access for maintenance.

✓ Provide safeguards for mechanical systems. Locate equipment in a maintenance area that does not transfer heat or vibration to the objects. Provide a constant power supply (including emergency generators), a monitoring alarm to alert staff to equipment malfunction, and adequate water supply, and drain lines.

✓ Include appropriate and sufficient moisture-absorber medium for passive control. Carefully calculate the type and quantity of silica gel or cellulosic materials to be used. The better the case seal the less absorber is required; the more surface area of absorber exposed the faster its responsiveness.

✓ Test and monitor the case. Evaluate the initial performance of active or passive systems before enclosing objects. Monitor the relative humidity for the duration of the exhibit to alert staff when maintenance is required.

C.8 Pollution-Control Systems

✓ Incorporate enough absorber to remove pollutants for six months to one year. Objects must never touch a chemical absorber.

✓ Ensure unrestricted airflow. Case design should encourage passive air movement across the surface of the pollutant absorber. Ensure that the case is well-sealed.

✓ Provide access to change the absorber. A small access port can serve both moisture and pollutant absorbers.

✓ Maintain the absorber. Renewal of activated charcoal is critical to prevent secondary outgassing. To ensure continual filtration, both activated charcoal and potassium permanganate must be replaced when exhausted.

D. Installation and Maintenance

D.1 Choosing Conservation-Appropriate Materials

✓ Select conservation-safe materials. Use high-quality, non-hazardous materials to construct case interiors, and case furniture. Avoid materials known to outgas, become acidic, or lose their physical or chemical stability. Consult lists of materials that have been researched, talk with other museum professionals, and test proposed materials.

✓ Avoid adhesives when possible. If necessary within the object display area, use a conservation-quality adhesive with a successful track record in exhibits, such as one based on tested resins--acrylic, polyvinyl acetate, or certain high-temperature heat-activated adhesives.

✓ Review the composition of commercial interior finishes. Select 100% acrylic paints with low volatile emissions for wood and metal surfaces; powder coatings can also be used for metal surfaces.

✓ Allow sufficient curing time before installing objects. Caulk sealants and finishes require a minimum of three weeks to reduce emissions.

✓ Isolate objects from painted or varnished surfaces. Separate objects with a mount or a layer of inert paper, foil, or other acceptable barrier, such as polyethylene or polyester sheeting.

✓ Select and attach decorative fabrics with care. Check fabrics for dye stability and fastness; prewash and dry them before installation to preshrink and remove excess dyes and finishes. Use a mechanical attachment method or sew fabric to itself; archival-quality double-sided adhesive tape is useful for temporary exhibits.

D.2 Using Less Stable Materials

✓ Use the least hazardous materials available, and isolate objects from them. Apply barrier coatings, foils and laminates to isolate wood and wood composite surfaces that are close to objects such as within display chambers.

✓ Aerate the case. After applying coatings and sealants, allow enough time for curing before installing objects. A minimum of three weeks is recommended, with case doors open and vitrine bonnets removed.

✓ Isolate objects from problematic surfaces. Wood products, even when coated, must not come into direct contact with objects. Physically isolate objects with safe fabric coverings, acid-free paper or board, foil, or an acceptable plastic barrier such as polyester or polyethylene sheeting.

✓ Incorporate a pollutant absorber or scavenger. Both activated charcoal and potassium permanganate absorbers can be introduced to ensure a pollutant free environment.

D.3 Design and Fabrication of Exhibit Mounts

✓ Design and fabricate mounts for object installation ahead of time. How an object will be displayed and what type of mount is required are early design decisions. Use a qualified mounting specialist who has conservation training; some objects require the direct involvement of a conservator.

✓ Protect the integrity of the object. No object can be physically altered or dismantled to accommodate placement or mounting in the exhibit. Use mechanical designs to lock mounts in place.

✓ Support the entire object. The object's center of gravity or originally intended attitude should be considered when designing a mount. Support provided by the mount must prevent physical stress or unbalanced weight distribution.

✓ Provide adequate support for flexible objects. Create custom-padded mounts for organic materials that support the structure over its entire contour. Textiles, papers, organic materials, and other susceptible objects should not be creased or folded, nor should heavy objects be placed directly on top of them.

✓ Support all parts independently. Fragile objects, including textiles, should be supported over as large an area as practical. Attached parts, such as straps, may require independent support.

✓ Stabilize objects from vibration. The mount design should reduce vibration when a case is opened or bumped. A cushioning material is often required. The mount should fit the object with precision to prevent vibration and abrasion.

✓ Ensure the security of framed works. Attach them to the wall with appropriate hardware such as "D" hooks and braided metal wire. Anchor the wall fastener firmly to the wall and be sure that it can support the weight of the framed object.

D.4 Exhibit Production and Object Installation

✓ Avoid transporting objects into production areas. Ensure the safety of objects during measurement and fitting sessions. Implement techniques to reduce, contain, and collect dust in areas where objects must be transported.

✓ Inspect exhibit assemblages that affect objects. Include several inspections during the production phase to ensure that the preservation elements are built to specifications. Test and approve exhibit cases with conservation features before object installation.

✓ Complete construction before object installation. The exhibit area should be cleared of debris and dust.

✓ Evaluate the exhibit teams performance. Review the exhibit process and evaluate the exhibit environment to assess how well the final product addressed the initial conservation concerns. Include any improvements and adjustments to the exhibit process for the next project.

D.5 Exhibit Maintenance

✓ Provide a maintenance manual. Document the construction details, lighting, and conservation features for future reference. Outline procedures and schedules for maintaining the exhibit and conservation criteria for the objects.

✓ Monitor exhibit conditions. Assign a staff member to inspect the objects daily. Any controlled environment--either in the overall exhibit space or in a case--must be monitored to identify when maintenance is necessary.

✓ Perform necessary maintenance. Replenish relative humidity and pollutant control systems as needed. When replacing lamps, refer to the maintenance plan for the lamp type and aim of the beam. Monitor light levels after the new lamps have been installed.

✓ Keep the exhibit area clean. A regular cleaning schedule facilitates preservation of the objects and offers an opportunity to assess any change in the conditions of the exhibit or the objects. Consult a conservator for appropriate methods and products.

✓ Plan ahead for the safe movement of objects. During object rotations and inspections or at the close of the exhibit, systematic removal of objects is necessary and requires proper equipment. Before beginning demolition of an exhibit, ensure that objects are carefully removed.

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THE RITUAL AROUND REPLICA: FROM REPLICATED WORKS OF ART TO ART AS REPLICA (Part I)

Sally Malenka

In a museum culture, objects considered unique, original, or of outstanding craftsmanship are the foundation of acquisitions, collections care, and exhibition. An original may be understood through the concept of time, or that which comes first in narrative time, and establishes an author behind the creation of the work of art. Much of our effort as conservators evolves from understanding the effect of time on the artist's intent or use of the object, or the effect of time on materials. The term "replica" would at first suggest an opposing concept. A replica must be that which comes after the original. Still, a replica is part of the same narrative time of the original, and this makes it the "excitable object" discussed in Part II, affecting our perception of the object, the author-effect (the aura of the author), or the narrative space. The replica must refer to or substitute for, and in some cases define or re-define the original, but always reveal itself as distinct (Millhauser 1995:51, 53).

Knowledge of the space or location, time, scale, style, history, and material and techniques exposes the replica. This paper will illustrate examples of replicas from the sculpture and decorative arts collection of the Philadelphia Museum of Art; (museum identification numbers are indicated in parentheses after the object name). Part II steps back from the art historians' interpretation of original and replica to explore the term "replica" from a philosophical point of view.

For the conservator, replicas may be a tool for compensation for part or whole of an object. In the straightforward example of a pair of Argand lamps, ca. 1840, (1946-074-001, -002) the top ring to support glass prisms was missing on one of the lamps.[1] A mold was taken from the extant ring and a replica was made by electrotyping. The copper electrotype was electroplated with silver, and epoxy was used to reinforce the back and interior of the electrotyped shell. The compensation creates the illusion of the pair of lamps in their entirety, and the replica is undoubtedly an accurate replacement for the missing component. In the next example, however, the replication is undoubtedly an incorrect interpretation of the original, although the illusion of completeness is effectively attained. A jade inset was missing from the top of a Qing dynasty incense burner (1935-010-028).[2] A photograph of the object at the time of acquisition showed the presence of a jade inset, although its form and design are not visible and there is no written description. The object was displayed in an 18th C. English period room, and the loss was significantly distracting. A decision was made with the curator to compensate this loss with a copy of a jade inset from an intact incense burner of the same period. A silicone rubber mold was made of the jade and the replica cast in polyester resin, tinted with dry pigments. The polyester replica was mechanically secured to the lid with a threaded rod and nut through a pre-existing hole. The replica in some way evokes a sense of jade, but in no other way can it be considered correct for the object, and it has no direct reference to the missing original. The context for the replica has shifted the identity: when a replica is part of an object, it occupies the same narrative time and space as the original, and thereby allows the deception to be believable.

Replicas may also be made to preserve the entire object, usually in anticipation of loss of or wear on the original. William Rush's 1825 wood sculptures, *Allegory of the Schuylkill River (Schuylkill Chained)* and *Allegory of the Waterworks (Schuylkill Freed)* (12-1937-001, -002), were originally situated above the entrances of the millhouses of the Fairmount Waterworks.[3] The precedent for replacing William Rush's fragile outdoor sculptures was set as early as 1872 when *Nymph and Bittern* (021-1940-001) was cast in bronze, a material in which Rush never worked; the bronze is on display at the PMA (Bantel 1982: 114-117). The casting was prescient. By 1900 only the head of that sculpture remained and is now at the Pennsylvania Academy of the Fine Arts. In 1939 casting of only the head of *Schuylkill Freed* was proposed as a "very acceptable piece [for the Phillips Academy] to represent Rush in the absence of an original work", although this was never carried out.[4] In 1978, fiberglass reinforced polyester replicas of both *Schuylkill Chained* and *Freed* were made, an improvement over metal to interpret a white painted wood surface, and now sit above the millhouse entrance. The originals were conserved in 1982 and are displayed on long term loan at the PMA from the Commissioners of Fairmount Park. The molds were destroyed to preclude the possibility of other copies. The fiberglass copies, 22 years after their fabrication, are now being considered for conservation by the City of Philadelphia. In the case of *Nymph and Bittern*, the bronze replica, in combination with written records and graphic images, defines our knowledge of the original. In the case of *Schuylkill Chained* and *Freed*, the replicas physically occupy the narrative space of the original. If the impact of the original is diminished by removal from the site, the impact of the replica is enhanced, and its care and preservation is approached in a manner in keeping with an original work of art.

Replicas may be used to define and preserve something less tangible than material: the legacy of an artist. Thomas Eakins' plaster working models were cast in bronze by his wife, thirty years after Eakins' death.[5] Although they were never intended as finished artworks, many of these objects may be found in museum and private collections, "[representing] a complex history of the artist's working methods, the promotion of the artist's reputation by his wife and students, and a history of collecting including the casting and recasting of sculpture" (Meighan et. al. 2000). The museum casts are now the subject of research and conservation to evaluate the sequence of casting.

Once an entire object is replicated, the replica itself may assume a status or use, particularly within the museum context, that is equivalent to the "original". The existence of a unique replica may enhance its perceived significance. Hector Guimard's tray (1949-043-001), like other examples of Guimard's work including that of the Paris subway stations (now largely replaced by replicas of the originals), is a superb art nouveau design. The original is a fire gilded copper alloy tray, signed and dated 1909, now in the Musée des Arts décoratifs, Paris (Inv. 18101). Guimard duplicated some of his works for use in his home, and the PMA tray is an electrotype copy of the original. He did not choose to have multiple originals made by casting, and the electrotype is not signed.[6] The gold electroplating on the electrotype was worn away in the center, and was treated with nitrocellulose lacquer tinted with dry pigments. The replica successfully substitutes for the original because of the lack of multiple copies, the close association with the designer, and perhaps because the image of the object is not immediately familiar. The museum label simply reads "gilded copper" and neither reveals or denies the existence of the original.

In the 19th C., replicas of originals were considered appropriate acquisitions for a museum or collector, to allow juxtaposition of objects for scholarly purposes (Haskell and Penny 1981:117-124). They may still function that way today. 19th C. plaster copies of sculptures from the Medici Chapel in Florence, *Dawn*, *Dusk*, and *Lorenzo d'Medici*, were borrowed from the Metropolitan Museum of Art (013-1997-001, -002, -003). They were treated for display in the exhibition, *Rodin and Michelangelo*, in 1997; (the first venue was at the Casa Buonarroti, Florence, where replicas were unnecessary).[7]

However, often 19th C. copies became generations removed from the original molds and the quality of the copies declined (Haskell and Penny 1981:123). Processes of copying, including sand casting, stone pointing, and electrotyping, became increasingly mechanical and allowed multiple copies to be made, sometimes without regard to the original material. The Milton shield (1984-133-001) is such a copy, an electrotype of a repoussé silver and damascened iron shield in the Victoria and Albert Museum.[8] The original was designed and crafted in a Renaissance revival style by Leonard Morel-Ladeuil for Elkington and Company, and was awarded a gold medal at the Paris Universal Exposition of 1867. Many copies of the shield were sold over a thirty year period to individuals and museums to disseminate knowledge of the work "necessary to the progress of art" (South Kensington Museum 1873:A2), to allow ownership of an image of good taste and design, and to recoup losses for Elkington and Co. for the expense of the original (Elzea and Elzea 1976:101). The PMA shield has been the impetus for extensive research to investigate the appearance of the copy, the techniques of plating, and the degree to which it approximated the appearance of the original. It has been displayed in the permanent galleries since 1995, its significance found not only in its reference to the original, but also in its process: a new technology applied to reproducibility.

If knowledge of the reference is lost, the narrative is interrupted, and an object may enter the world of fakes. A 16th C. Italian mirror (046-1991-001) was brought into the lab for purchase consideration.[9] After examination under the binocular microscope and by x-radiography, the mirror was revealed to be an electrotype replica. The story was pieced together, when the original, a damascened iron mirror at Ecouen outside of Paris, was found, and another electrotype was uncovered in the electrotype collection of the Victoria and Albert Museum. Modern cast white metal replicas are still available for purchase at Ecouen today.

Period rooms, when viewed through the lens of the concept of replica, reflect varying levels of authenticity and replication. The period rooms at the PMA were collected under Fiske Kimball, architectural historian and director of the museum between 1925 and 1955, and one of the leading proponents of using period rooms to establish context and history for art objects. All period rooms have an element of replication, whether in concept, in location, or in material, a fact not lost on contemporary critics of Kimball's approach (Conn 1998:225-230). Collectively, the period rooms may be considered replicas of an idea, and one that can never be truly experienced: Kimball's evolutionary walk through time (Conn 1998:226). When we enter a period room, our perception of the object shifts from viewer to participant. The Lansdowne Room (1931-104-001), an 18th C. Robert Adam Room, and the Hotel Letellier (1928-052-001), an 18th C. French room, retain much original material, accurate interpretation of replicated material and close approximations of original dimension and experience of space.[10] We call these rooms original or authentic, because replica of part does not overwhelm the authenticity of the whole. Each has been the focus of extensive research and conservation. On the other hand, the Medieval cloister (1928-057-001) is made up of columns and capitals from sites in the Rousillon region of France, and includes some modern pieces. For decades after its acquisition it was referred to as St. Genis, until recent scholarship clarified that only four columns and capitals undisputedly came from that cloister, which had been disassembled in 1924, eight others were from the same period and region, and the rest modern assemblages.[11] In 1988 the museum supported efforts to allow St. Genis to rebuild its cultural heritage, by providing silicone rubber molds of the capitals at the museum.[12] The replicas remain replicas in their material, but they now also have an authenticity of location that the originals no longer do. They are *metaphorical* replicas by *substituting* or standing for the original. The early 20th C. interpretation of a French salon, from the New York home of Mrs. Eleanor Elkins Rice (1939-041-062), is perhaps the best example of a room as *metonymic* replica, where the room *refers* to an idea, based on designs by the French architect Jacques-Ange Gabriel (1698-1782), but without direct reference to an original. The room is situated between two "authentic" French period rooms in the museum, and excellent 18th C. furniture and ceramics are displayed. In spite of clear labels interpreting the room, the illusion is effectively complete.

Scale models are also types of replicas, but their deception is far more obvious. A model of the Chinese Reception Hall (1929-163-001) made in the 1930s during the WPA was reassembled during the treatment of the painted ceiling.[13] Plans for the model include eventual exhibition, which is somewhat surprising when the original and authentic room, accurately interpreted in its replicated parts, is only a few steps away. The change in scale- the model is 6' x 5' and the room is 40' x 35'-- allows an enjoyable shift in perspective for the viewer. Importantly, the deception is immediately detectable visually, and differs from the example above of the Rice room, by requiring no other intellectual background or knowledge of original.

In all of these examples, replicas may assume a status in the museum that includes preservation. In the 20th C. through the work of Marcel Duchamp, the potential for all artworks to be replicated is re-envisioned as the replica as the work of art. *Paris Air* (1950-134-078, -78a), one of Duchamp's readymades, will serve as an example. The first version was an ampule of serum, emptied and resealed by a pharmacist, which Duchamp gave to his patrons, Walter and Louise Arensberg, when he returned from Paris in 1919. The second version, also a gift to the Arensbergs and at the PMA, was made in 1949, after the original one was broken and repaired. A third version dates to 1963 and an edition of eight was made in 1964, authorized and approved by Duchamp, and thereby redefining "readymade". Even on Duchamp's own terms, "In art, and only in art, the original work is sold, and it acquires a sort of aura that way. But with my readymades a replica will do just as well" (Naumann 1999:293), it is still impossible for us not to become entangled in words: "original readymade", replica, version, copy, or edition, and question, rightly or wrongly, whether the original concept is present in the later editions.[14] For conservation reasons, the first *Paris Air* has never been loaned from the museum; the 1949 replica has traveled several times. In the end, the existence of this and other replicas has aided the preservation of the earlier versions by limiting loans of the more fragile, more intact or more deluxe versions of his works. We remain bound to the idea of earliest, first, or original.

Sherrie Levine responds to Duchamp's lead and plays with ideas of originality by appropriating the artwork of those who preceded her. Levine created *Newborns* in 1993, as an installation in the Museum Studies series, where an artist is invited to make new works that respond to the PMA's collections. She selected Brancusi's 1915 marble sculpture, *Newborn*, as her departure point. The role of the conservator was critical in making a high quality mold and cast of the original.[15] Levine then had six casts made in glass. These were displayed on pianos, a direct reference to the display of a Brancusi *Newborn* at Kettle's Yard , the home of H.S.Ede in Cambridge, England. As viewer's we are placed in an uncomfortable and ambiguous position of original-replicas-new original.

Of these examples, which truly fit a definition of "replica"? Should we limit the term to only those works where the artist is the author, or authorizes the act of replication? Are the examples of replicating for compensation of part or whole simply examples of copying, or do meanings shift when a viewer is deceived? And who is the knowledgeable viewer-- the scholar, the educated public, the conservator with scientific tools of detection? Does the identity of a replica change when it receives in the museum the same care, display, and status previously reserved for the original? Underlying these examples are changing attitudes and theoretical underpinnings toward replica and original. For the conservator called upon to treat or evaluate a replica, the challenge is in understanding its relationship to an original, while respecting that the replica too has a significance distinct from, but not necessarily less than, that of the original.

Acknowledgments

The projects and treatments included in this paper represent the work of many individuals over many years. They are credited by endnote citations. I would like to thank particularly Andrew Lins, Melissa Meighan, and Donna Farrell.

Endnotes

1. This object was treated in 1989 by Sally Malenka.

2. This object was treated in 1989 by Sally Malenka.

3. The replication of these sculptures was carried out in 1978 with the coordination of the Conservation Department of the PMA, headed by Marigene Butler. The treatment of the sculptures was carried out by Andrew Lins and Richard Kerschner in 1982.

4. Marceau, June 19th, 1939. Marceau had also proposed the replication of both sculptures in 1937 by casting in metal, possibly aluminum; this too was never carried out.

5. This research and treatment is currently being carried out by Melissa Meighan for a forthcoming publication and exhibition. Julie Solz and Catherine Williams have assisted in the project.

6. The tray is composed of two halves, the front an electrotype and the back a spun copper sheet; the interior rim is reinforced with a lead solder, detected through x-radiography. The absence of the signature on the electrotype suggests that the copy was made from an original pattern rather than a mold taken from the cast tray.

7. This treatment was carried out by Donna Farrell in 1997.

8. This research and treatment was carried out by Andrew Lins and Sally Malenka in 1995.

9. Examination of this object was carried out by Andrew Lins, Melissa Meighan and Sally Malenka in 1991.

10. The Lansdowne Room was treated in 1986 by Marigene Butler, et. al. The Hotel Letellier was treated in 1995 by John Childs, et. al.

11. The examination and research was carried out by Eda Diskant, Department of European Decorative Arts, who published extensively on the cloister, and Melissa Meighan, and is summarized in PMA documents of 1985 (Conservation file 1928-057-001). The replication of the capitals was carried out by Andrew Lins in 1986-89.

12. Two other original capitals at the Louvre were also returned to St. Genis.

13. The model was reassembled by Mary Culver and Sally Malenka in 1996.

14. With respect to the Schwarz replicas, Naumann writes: "if [Schwarz] wanted to retain the idea presented in *Paris Air*..., for example, he would have had to arrange for the glass vials to be broken and resealed in Paris. Years later, at least one collector questioned whether or not Schwarz took this necessary step..." (Naumann 1999:249). For the 1949 replica, Duchamp arranged for the replica to be made in Paris (Naumann 1999:167).

15. Donna Farrell made the mold and wax positive in 1993; the wax positive was used by the glass maker.

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THE RITUAL AROUND REPLICA: FROM REPLICATED WORKS OF ART TO ART AS REPLICA (Part II)

Lucio Angelo Privitello

"Art is the historical-philosophical truth of solipsism, that in itself is false"
T.W. Adorno (1975: 73).

A short version of this paper was presented as a seven minute Video at the AIC 'Objects Group' meeting. Then, as now, my aim was to raise questions on the conceptual status of a replica, and allow a glimpse at theoretical implications if such questions were more fully pursued.

A replica is an excitable object. A replica comes to the philosophical questions of the 'Being' and 'Time' of originality stripped of its romanticism, its *Sturm und Drang*. An original holds fast against having its 'cue' (*entrée réplique*) uncovered. A 'replica', by definition and by acting on a 'cue,' questions the 'thing-in-itself' thought to be hidden within the spaces of an 'original's' miraculous escape from exchange. A replica enters the economy of exchange historicised and fully conscious, whereas an original hides this exchange that dwells as its unconscious debt. Within that space the replica vibrates, therein it is excitable, and from within that space the replica takes the place where nine-tenths of the idea of the idea of original 'property' is put into question. Yet, a replica persists in possessing a property of what it signifies, while questioning the solipsism of art's historical-philosophical 'truth,' as the above epigram from Adorno states. Is the 'truth' of art that it is a replication? And if replication is a kind of repetition, is it, as Kierkegaard thought, a place "when ideality and reality touch each other" (Kierkegaard 1983: 275)? In a way, a replica is a perpetuation of the original as a ritual and ceremony. A replica is an invested and saturated point of the ceremony of the life-history of an original. It is, as Kierkegaard felt a 'forward recollection' (Kierkegaard 1983:131).

A replica allows for shadows to be cast within the lighting reverently retained for "original" works. A replica is the materialist in the idealist camp of art. It is able to cast these shadows by revealing levels of conceptualization. Levels of conceptualizations can be seen as technical retakes, theoretical cues, contextual transformations, or historical citations. They make up the spaces from where one enters the 'story' of an object that while fascinating can be detached from the aura of aesthetic somnambulism. This detachment is where the work of art makes an about-face, where the ritual of aesthetic production exposes itself to the political grounds that sustain it. From mystery one gains a view of the struggles of mastery. A replica is that which enhances, and what foreshadows this view (Frank 1989; Davis 1995). These shadows allow us to measure the problematic concept of "intention," seen teleologically, since we cannot interpretatively scale intentions since objects, and texts are fundamentally mute about their openendedness. They are always the 'coming attraction'. I will call this the 'Thales replica effect'. Thales was said to have been the first individual to measure the height of a pyramid by "having observed the time when our shadow is equal to our height" (Kirk, Raven, Schofield 1983:84-85). With an original we are in a similar position, we scale it by the shadow that it casts and that only in relation to our time in its narrative time.

A replica can also be a work of art's secret agent. A replica allows one to determine if a work has accomplished or failed at the post-creative-partum of 'intention,' a crowning product of the involvement of art historians, curators, and conservators. A replica may also be a work of art's *doppelgänger*, its "mirror-image" which can at times work at cross-purposes with it, adding the climax of a catastrophic meeting so familiar in the works literary works of E.T.A. Hoffman, and in Dostoyevsky's character Ivan in *The Brothers Karamasov*. Seen in this way, a replica reveals an 'intention' previously unnoticed, or un-adopted. A replica can also be an original's prosthetic, as seen in the works of Sherrie Levine, Lucio Pozzi, Elaine Sturtevant, and Douglass Davis, just to name a few. It is also clear that it is not possible to defend the position that a replica, in the cases just mentioned, doesn't feel the phantom pain of an original. Actually, a replica is an extension of the body-schema of an original, and within the considerations of conservators and curators much pain goes into caring for and about them. This is where comparisons can be studied, and where a rethinking of standards and practices of which 'intentionality' is most problematic, gains a fresh impetus for technical, conceptual, art historical and scientific re-discoveries. A replica is a tool for such reevaluations of reasons and judgments in the sciences and no less so in the arts. A replica is the Devil of a narrative's details. It is a phenomenon rich and saturated with history, and *contra* Benjamin, "*aura is an artifact of history*" (Margolis 1999:116-117).

Apart from Hillel Schwartz's *The Culture of the Copy: Striking Likenesses, Unreasonable Facsimiles* (1996), little has been seriously written about the phenomenon of 'replica'. Even less has been hitherto written about it as a phenomenology of the replica. This is mostly due to its misappropriation under the mythic lights of "original". This initial misappropriation set the investigation back into the "Genetic" trap that was pointed out by Monroe Beardsley 1981: 457-460). The 'Genetic' trap is when a work "refers to something existing before the work itself, to the manner in which it was produced, or its connection with antecedent objects and psychological states" (Beardsley 1981: 457). A replica isn't there to show how an original set out to accomplish its intention. Intention is but the crowing of ideas from practices of a community of culturally involved agents. A replica reveals how an original lacks intention, in having always already given its best intentions away.

An example of the misappropriation of the effect of the replica is seen in the 1985 text edited by Kathleen Preciado entitled, *Retaining the Original: Multiple Originals, Copies, and Reproductions*. Only two out of the thirteen articles collected mention the term replica as part of their title, while the collection of articles set replica squarely back into the "Genetic" trap of an original's intention. In the article, "Copying in Roman Sculpture: The Replica Series," by Miranda Marvin, (Preciado 1985: 29-45), no serious thought has been given to the social *a priori* concept of the replica. Instead, we receive a detailed view of Cicero's requests and dealings for sculptures at his Tusculum villa. Based on a closer look at Ciceronian ideals in both the arts and more importantly in rhetoric, a replica is an object that imports the surroundings of a once intact original as an exercise in the emulation of character. For Cicero, the replica is what constantly bedevils one of the past as a time only filled by the presence of the present. A replica, for Cicero, was a learning device to focus one's powers on a cultural reinvention based on the personality that orchestrates. This view was already mentioned by Plato, especially in his dialogue *Sophist* (235d-236a), and *Republic*, Books II, III and X. A replica is a spark for moral regeneration and emulation. It is the closest one can come to the lofty enactment of the Platonic Forms, and for Cicero, served as the bond for a social *a priori* where each individual may fully realize their particular forming of the ideal 'Form' of the social fabric. Cicero anticipated what many call postmodernism by centuries in his theory of personality absorption cut adrift from the anchors of historical time. The hybrid was born, and acculturation found its nemesis; that a culture is the replication of what a culture lacks: more time. Replication exposes the seductive hypocrisy of 'givenness' by how it reveals that value is an understanding begotten through reproduction rather than the consumptive production of an effort.

Something similar applies to the so-called "workshop replica" (Brown 1985: 111-124), where assistants, in this case to Paolo Veronese, worked along with the master, and prepared versions of his canvases "replicated...for the mass market" (Brown 1985:112), but also seeking an internalization of the ideals and gestures of the master; again to give them more time. A replica is a door that allows access to the life-world of a style. Without the replica there is no learning of the trade. Brown's article, "Replication and the Art of Veronese" seeks to define 'replication' along these lines by pointing out the differences between "copy," "autograph replica," and "workshop [bottega] replica," each outlined against the original of "*di sua mano*" quality. The theoretical outcome of this unfortunately anchored derivation is that certain pieces are considered less 'original' than others, in the ascending order, "copy," "workshop replica," "autograph replica". Instead of viewing a replica in the straightjacket fashion of original Inc., it would be more fruitful to perceive the phenomena of the replica as investments from which so-called originals eventually profit. At this point it would be well worth comparing the positions of the critical theorist T.W. Adorno (1975: 72-73, 91-96, 288-290), with that of the Marxist theorist G. Lukács (1973:148-176). For Lukács, without a mechanical mirroring of the dialectic of phenomena and essence, or art as the reaction and copy of the external work, it would be impossible to be oriented in life. He felt that this was always part of our most basic perceptions that seek to establish the relation between forms of consciousness and the objective world. Adorno's position opposes this, seeing art is the refuge from mimetic behavior. Lukács misses the point in his critique of modern art's formal qualities because of his dogmatic unity of universal and particular, where a place is left standing of some desperate idea of a "normal work of art" (Adorno 1975316). The master's hand is left standing in the critique of Lukács, whereas in Adorno, the hand that seeks mastery is problematized by the erasures that it leaves upon the work it seeks to totalize. For Lukács the original is found in pieces everywhere. For Adorno the original is the wake of its consumed marketability.

Upon closer study, an "autograph replica" is not quite an "original replica," as the *Paola and Francesca* of Ingres (Krauss 1985: 151-179), points out. Or is it? In the Krauss article, it is implied that to "replicate" is to make a "multiple copy". If this "multiple copy" is executed by the Master's hand, it is also then an "original replica". Why then is this not also an "autograph replica"? This perpetual shifting about of the concept of "replica" is what I will call a replica's inherent metonymy. It makes up part of the *levels of authenticity* that an "original" already performs upon the fabric of historical and art historical references. Certain critics see the reworking of Ingres' own work as an "auto-plagiarism," while Krauss sees it as a "practice of seriality". In this arena of study, "seriality" is a far better term than that of "multiple originals". "Seriality" comes closer to how the work of art's *effects* shows its dependency on replication *tout court*. It is replication that, *contra* Walter Benjamin, is aura. The replica is merely the embodiment of replication's curse on the hubris of the original. It is the hero that rips through the tightening backdrop fabric of artistic style and technical achievements to find itself staring at its own strings, at the mechanisms that figured it, and that made it dance. The replica is the repetition as "acting out" of this trauma of the original. The original is rewarded for the work that the replica and endless replication has on the analysis of a work's moment in historical time. A replica is a stripping in-itself whereas an original is what wears itself out as the icon that it will shrink back from. Replication is the precondition for an origin, and enshrines the icon within the delicate arch reminding us that aesthetic childhood has past.

Barely beyond these social ties, the replica is the operation of dissemination rendered as an object to be enjoyed again and again, while capturing the "mark [that] is structurally multiple and [which] cut[s] off from itself in advance, form[ing] the thrust of a philosophical argument that has great resonance with any discussion of models and multiples..." (Krauss 1985: 157).

The ritual around replica is played out in these parameters, parameters embraced by a museum culture, where bets are cast on concepts such as original, copy, multiple originals, (which are isomorphic copies, the artistic 'serial'), replicas, and art works made as replica. Yet, it is all placed under the vitrine of culture. The mythic light of 'original' is softened by these rich shadows that are cast as the ensemble of questionable objects, but it is the museum that first and foremost engulfs the presentation itself as 'original'. Such a context can be compared to what in scientific practice is known as "perfect, or exact replication" (a myth, no doubt), which serves as a standard for reliable research. The concept of 'replica' is still held prisoner within these parameters.

In museum culture, each institution measures itself against the setting of the "history of art". This concept of "art history" lies within museums as the promise of an adequation from outside. It is where the setting of the museum, and where the analysis of the collection works as a narrative thread or as a quantitative count of parameters, which will, in the long run, be deemed art historicaly worthy. It is only when one or the other of these settings, (the within or without), are determined that a notion of replication can be defined. In a modernist tradition the 'inside' claim was too rich, situating the 'outside' as extension of its measure, whereas in a postmodernist vein, the 'inside' poverty is not yet great enough for anyone on the 'outside' to be deemed a suitable patron. Replication is to work within one of these chosen vocabularies and practice, which *in media res*, show them both to be false, since vocabularies and practices base themselves on little else than repeatable observations. In museum culture these vocabularies and practice more readily, (and must readily), feed the ever hungry concept of original, whereas in a scientific community it would extend the original into the aura of replicability. The ability to replicate guarantees success for the 'truth' of shared scientific knowledge, whereas in the world of art, (history of art, museum culture), it can be seen as an undermining of the function of an original. "In a sense replicas do not exist at all, since their being derives entirely from other objects, but in another sense they have an enhanced or double meaning" (Millhauser 1995:50).

This is where the aforementioned *doppelgänger* of the work of art, its secret and diabolical agent, come into play. This is the replica as a tool that accomplishes what is not yet manifest in the trauma of the original. Its explicit dependency, while revealing that implicitly it's interpretation is truth. It is in this sense that a replica is, as Millhauser noted, a "haunted object," haunted by the epistemological limits that it must drag about as chains to any truth-value statements made within the aesthetic mansion that it ceaselessly travels. A replica is an attempt at understanding the *ontological* status of works of art, which it greets in the tatters of its *ontic* robes. It alone is the 'truth' of the 'being' of the original's temporal meaning. Replication is a study of what makes up the ground of the nomination of the original. Yet, a replica seeks to undermine the fetishism of the very original that it admires, leveling the notion of transcendence that museum culture wears as a mask (Adorno 1981:175-185; Sherman, Rogoff 1994:123-139).

The original is part of this syndrome. It is a masked replication. It is this masking by including intermediary documents, imported mediums and contacts with various traditions that are entwined onto the forming of its location in a social *a priori*.[1] The composing of these parts, which are forms of operational replications, contribute to a whole to which the idea of original also belongs, as art to non-fiction.[2] An original always already marked its replicability as its historical necessity. A parallel can be easily seen by studying the genre of biography that has its versions, updates, omissions, rediscoveries, and re-inventions. The structure of replica instead is the paradoxical reenactments of singularity and a critique of the autonomy of the 'original' based on the consumption of works seen as "new" or as wish-fulfillment, as in blockbuster exhibitions. The original is a mourning for historical loss, whereas the replica is the melancholy of that loss.

In a strict sense, bodily identity is the first object that calls for *compensation of loss*, whether in part or whole. This can be seen in the example noted in Part I of the Argand lamps or the William Rush 1825 sculptures replicated in 1978. The former is an example of how replica is a replacement of a narrative space. The latter is a fine example of the replica as equivalence of use. In a community driven to preserve, the ground to the conceptual sense of replication, (whether as narrative space or use), lies in the retaining of singular intention in parts in-and-as the cultural *a priori* of the whole. But the shift from one to the other is also a shift in how one reads the term replica. A paradox will also surface when the call for preservation must allow exposing said intentions to serial processes.[3] On a more somber reading, replication can be seen as a technique *qua* work of art, which renders unto history history's dues. Exposing itself as the "fill" *and* the object to be conserved, this technique is the provocation of the 'counter-concept' that inhabits the

art world and that makes up the concept which is cherished as the beloved original.
Because of these issues within the ritual around replica, it is advisable to note what a condensed history of the term "replica" may tell us about these dilemmas. Following the advice of Ludwig Wittgenstein, "sometimes an expression [or term] has to be withdrawn from language and sent for cleaning, - then it can be put back into circulation" (Wittgenstein 1980:23e).

"Replica" began as rhetorical device expressing identity in narratives. Today it is used in methodology studies in the philosophy of science, statistical psychiatry and physics. 'Replica' from the Latin term *repetitio* and *repeto* means 'ask again,' 'take steps to recover,' or 'seek to restore to a condition'. This term points to a prior model reflected in the linguistic root of the Greek term α ν α φ ο ρ α (anaphora), meaning 'appeal,' 'recourse,' or 'reference'. The use of the term 'anaphora' in figures of speech is specifically directed at a repetition of beginnings. Its use makes the 'subject' or 'action' memorable, yet the 'repetition' of the term could not be considered a 'replica" since the sentence which follows is usually added to expand the conceptual field of reference. It is in the French that the etymology of 'replica' (*réplique*) is used to its fullest, in conversation, in theater and in the arts (Imbs 1973). Because of this, Duchamp as a phenomenon was bound to happen as the epitome of *donner la réplique*, which means the perfect timing of a response given when and only when another plays opposite. Little wonder that Duchamp left art for chess, threw a urinal in the face of those who later will admire it, and left close to a dozen *Paris Air* readymades (Margolis 1980: 85-86; Naumann 1999).

If the common definition of "replica" as an "exact copy of a work of art" (Turner 1996: vol. 26, p. 221), is retained, then the entanglements of the issues that replicability has within the scientific methodology will continue to plague art history. One of these entanglements entails the confirmation and corroboration of competent agents and experimental conditions. In the aura that perpetually sustains works of art, this can be seen as something "artifactually possessed by the object" (Margolis 1980: 86). But this is the trumping up of intentions by conclusions from given experiments, (art historical thesis), and whether said conclusions can be observed, (or repeated), under identical circumstances. Museum culture makes sure this will be as close to the case as one can come, hence the 'inside' overtaking any and all unadequated 'outside'. What will be made of the subject matter of the experiment, (or art historical thesis), will also determine if the validity, or not, of the 'object' does in fact possess said artifactual quality. The circularity is astounding, and replicas merely point out that notion. This is the exposure of what Adorno called "the historical-philosophical truth of solipsism, that in itself is false" (Adorno 1975: 73).

In the subject matter of art the replica causes a more dialectical process in the study of what can be considered the "same". A replica and replication is the movement of the dialectic, its center notion, which is mixed with the vacuity of the original's Being, as it is with its own Not Being the original. The subject matter of art, of which the work of art is a symptom, bars strict originality because replicated data is constantly being used and reinterpreted. The history of the subject, the unfolding of its history is a becoming replete with expectations, creating instability for the study of strict-original as it does for strict-replication.

Instead, a replica is a methodological response to a search for an author-effect, and is a reevaluation of knowledge claims. This can be seen in artist-curated shows (Orozco 1999), which call for a discussion of a dialectical nature as the key player of the exhibited product. In this case a replica is the thread of cognitive occurrence stretched to the limits of its pile. The thought as technique comes to its limit, and only worship is next in line as a saturated phenomenon, or with any amount of luck, of reflexive critique. Both are rites. Yet, at no point is there an unavailable original to such an unworking or dream of a Platonic Form, forever out of reach, forever haunting, forever desired. An original is the price that a replica pays for trying too hard. This is how one reconstructs objects in, from and as having a tradition. These are construed by intermediary documents that *refer* to *meanings*, otherwise known as original aspects in an ongoing negotiation prey to a collective objective or "method effect" (van der Veer *et. al.* 1994: 25, 94, 100-104).

Original is an epistemological *meaning*, whereas replication is a methodological *reference*, where meaning may differ by the variation of the referents, just as learning new sets of rules will form new kinds of judgments and games. This would be the conceptual sense of the possibility of replication as the very grounds where originals are born. A replica is not a reasonable substitute for an original, but is it the reason for an original in-and-as the first place. An original is the mark of the historical destiny of the individual folded back into the work that has turned its face from the market that permits its sale.[4] This is where a replica finds re-pose. The rest is, paradoxically, in the very disturbance around the re-execution of the original, which is the excitable object.

A replica's having form, its material perseverance, is a play within this conceptual play of *levels of authenticity*. Because of the cognitive occurrence at the limits of testability, deception itself gains the methodological importance it always had, psychologically speaking. This would raise replica to the status, already mentioned, of the *doppelgänger*, and with it sublimation, screen memories, displacement, and condensation would enter into their own as factors in a list of conceptual replication. Within this list, the original object would be just one of many points of references behind the Oz-like scrim of ongoing *adequation* to an original trauma. The intervention sought in these relations, (and not unlike that of the construction of a Period Room), is the stabilization of the name of the further back as legacy, by the preservation of materials in future time. Yet, these forms of preservation are also being challenged by techniques difficult to preserve as seen in Anderson (2000). Replication, as seen in Period rooms, and counter to the examples from Anderson (2000), is the adhesive for the temporal dialogue where enculturation is its product. In this kind of event, and as George Santayana wrote, "to observe a recurrence is to divine a mechanism" (Schwartz 1996: 291, 192-199). In the "media-saturated world" this is reversed, it is where we seek to observe the divine as the recurrence of the mechanism. The worship factor that was next in line as a saturated phenomenon, at the breakdown of the engulfed product in the narrative space of being hyper-exhibited, now becomes the rites of visitation-passages encircling a critique in the practice of a metaphysical homelessness. The heart of 'original' has stopped beating, and the mechanism we divine is intimated by our capture within good curatorship, and even greater conservation techniques.

To contribute in the formation of this mechanism, as recurrent or repeatable effects, is to allow for the potential of an intimation of *originality* and its *reproducibility*. The conservator plays the role of another effect of the absent author of this volley. A replica's power of production is but an original's perverse fantasy of perpetual reproducibility. "What eats away at the life of an artwork is also its own life" (Adorno 1981: 184). A replica is part of the life of an artwork, its most excitable part, the part that is closest to the process of having rethought its own practices and its place in the ongoing show of the work fully historicized. An original is metonymic seizure. It is the point where the work has run out of things to emulate, and that is only after it has been ideated upon the edges of the replication of what was already stretched to the limits of its theoretical and practical fabric.

An original is situated in this play of levels and edges of authenticity. A 'copy,' unlike a replica is that which does not participate in the play, that which has nothing to gain by the loss it could incur if it had instead played into the space and time of the imaging of a forever after. A copy is that which is taken out of circulation from the annals of art historical practices, whereas a replica is a copy that enters into the repetition of the trauma of the original. A copy is a duplication; a replica is an emulation. The forever after of all originals is *metonymic replication*. It is the differal of signification by a trope that denotes an object that it does not literally refer to, yet to which it can be linked. In keeping with what Walter Benjamin stated, "one of the foremost tasks of art has been the creation of a demand which could be fully satisfied only later" (Benjamin 1969: 237). The object of art dreams replica at the summit of its dialectical stage, and as the very myth that creates the foundations of its rites. This would be the anaphoric quality of beginning again, within a history already begun. This is where replicas are the very grounds where originals are born, where they take their first steps in place of a creation *ex nihilo*. There is none, as there are no originals that are not first product of the limits of replication.

Within this chasm, the line that divides what *refers* (metonymic replication) from what *substitutes* (metaphoric replication) is where the work of *criteria* must be founded and questioned. If the object of comparison is not clear then historical reconstruction is open to the charges of a 'programmatic hypothesis,' meaning that the evidence of an original becomes a *metaphorical replication*, a substitution *in absentia*. In this case, the work is a *tableau vivant* of the very practices of its documentation, and where even beautifully crafted, is wholly embraced by the problem it longingly turns to address, only to there find itself rendered mute.

The Hellenistic copying of masterpieces, Cicero's villa at Tusculum, the 19th Museum of Copies in Paris, the Victoria and Albert cast court, and re-creations in the Diaspora Museum in Tel Aviv set the idea of original into the space and time of a forever after. In that space the replica enhances the original's power of reproducibility, while deconstructing the spatio-temporal frame of reference, their cultural-specific emergence. The opening that is created, the chasm, gives a voice to the observer to come, the futural more writerly viewers not present to the object that has come before, and is thus an *authentic replacement*. The replica addresses the power of the immaterial substance of an object's temporality by how the gaps in production between original and replica become part of the viewing experience.[5] The gap as chasm is sustained. A replica is thus about the identity of excitable time.

Replica is the *enfant terrible* of art history. It has been asked the fatal question, 'what can you give up and still be you?' and responds: the original (Schwartz 1996: 320). The replica is the *identity* where accountability and expectation are necessitated without contradicting the laws of identity. A replica questions the logic of the original by showing the grounds from which that logic operates. Replication, the art and ritual around replicas is the offer of the construction of knowledge as the question of 'style' and is the question of the ability of continued production and research.

Originals are a halt in the play of history, a syncopation in the voice of creativity, which, hoping for an ecstatic level, pay for their rise by the production of the replica that gives them the breath for their syncopation to last indefinitely. Originals are the hope of the broken, of the loss and of the chasm that is slowly closing. It is a history made to recede in the hopes that a glimpse will be cast back as a repetition of a true identifiable heritage that must be endlessly and quite impossibly compensated for.

Endnotes

1. The term 'original, from 'originale,' comes from the Latin *exemplum*, which derives from *eximo*. It is that which is chosen for its homogeneous qualities and from its being dug out or taken from a site. On a reading of total mimesis there would be no original to return to, no object itself, in contrast to the charitable ideals of recovery seen in Gabriel Orozco's statement (Orozco 1999).

2. See also Tessa DeCarlo's review of the San Francisco Museum of Modern Art exhibition "Fact/Fiction: Contemporary Art That Walks the Line," in *The New York Times*, April 9, 2000, entitled "Laying Bare the Uncertain Underside of the Truth". On a strong reading of the sublimation of real and fake, the concepts of "disguise and deceit" would also be sublimated, along with any other higher truth. This would leave Cindy Sherman's 1970 Stills and Yasumasa Morimura's 1996 self-portraits with no outside reference, nor potential for reinvention since the criteria for knowing would itself be blurred. Sherrie Levine's 1981 "copies" of two Walker Evans photographs would in this case be x-propriations rather than 'appropriations'. In art, logic is always at its most savage state, and very few individuals follow it out of epistemic fear. It is in the work of Tina Barney that we come face to face with this upshot, for according to this outline, the only thing that remains from her photographs that does not deceive is 'anxiety'. Anxiety is possibly the only criteria that may serve as a way to judge the properties and sedimentations of which the art work, after all, works as its art.

3. See also *Reconstructing the Mind: Replicability in Research on Human Development.* Rene van der Veer, Marinus van Ijzenddorn and Jaan Valsiner, eds. New Jersey: Ablex Publishing Corporation, 1994, pp. 167-168.

4. The works of the French performance artist Orlan can be seen in this way, (Smith 1993:C31), as well as the implications of the work of William Laziza (Powers 2000), and the more theoretically laden situationalist architect Constant Nieuwenhuys (Muschamp 1999). See also Arnold Hauser (1951) *The Social History of Art*, vol. 1, pp. 105, 109, 266.

5. Compare the 1:10 scale sculptures of Karin Sander (D'Amelio Terras Gallery, NYC, May 2000), or the sculptures of David Levinthal, Jeff Koons, or Claes Oldenburg, that work with scale as the transformation of surrounding contexts through perception.

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A CONTEXT FOR THE MAKING, USING AND MAINTENANCE OF REPRODUCTIONS AT COLONIAL WILLIAMSBURG

Chris Swan

In today's age of social history interpretation in living history museums, the use of thematic story lines has steadily increased, while object-oriented interpretation in general is diminished. Conservators constantly struggle to maintain historic houses with period objects in the face of thousands of visitors and dramatic storytellers. Because of the fragile nature of materials, and this growing indifference to period objects themselves, the use of reproductions in historic areas is on the rise. We seem to be at a crossroads between solely using reproductions for interactive educational programming, and simply exhibiting period objects. Colonial Williamsburg is in a unique position not only to make period reproductions, but also to use, maintain, and interpret them (in some cases, alongside collections objects) as an integral part of the visitor's experience. Whether we view reproductions as essential to an educational mission and therefore valuable in themselves, or just theatrical props, they are a reality in some of our historic houses, and, as such, deserve our attention.

One of our challenges as conservators lies in our ability to augment the interpretation of our cultural materials by our investigations into historical and material circumstances. In this context, the role of the conservator applies to reproductions and historic collections in similar ways. A conservator provides a thorough understanding of period construction, materials, effects of aging and deterioration, and also safely carries out molding and casting when exact copies are required. Moreover, a conservator can investigate design and construction details, and offer a protocol for distinguishing new objects.

Reproductions in a living history museum can take various forms as illustrated by two objects representing the Capitol building at Colonial Williamsburg. The first is a commemorative tea towel featuring the woven image of the so-called *Bodleian Plate*, an eighteenth century engraving of the capitol, along with the royal governor's palace and several buildings of the College of William and Mary. The plate was found at the Bodleian Library at the University of Oxford during the early days of the restoration of Colonial Williamsburg. The second is the actual reconstructed Capitol building itself. The tea towel, offered for sale at the Craft House Store and by catalogue, and the 1950's capitol building both are reproductions in their own right, both project the educational mission of the museum, and both support the museum with the revenue from their sale or ticketed presentation. The tea towel falls into the commemorative object category, derived from a historic subject but manifested in a more familiar modern form. Its primary function is to support the general operations of the museum. The capitol building, as a reconstruction of the original capitol, is partly based on the image from the Bodleian Plate, and partly on archaeological findings and other historical research.

From the time Colonial Williamsburg opened its doors to the public in the 1930's, several things became immediately apparent. First, it was obvious that the general public wanted to take home with them a small piece of the Colonial Revival they had experienced in the reconstructed historic village. Secondly, outside artisans started making reproductions of varying quality and fidelity to meet that demand. The Colonial Williamsburg Foundation determined to capitalize on this opportunity to educate the public and provide an outlet for such reproductions in a tightly controlled Restoration Reproductions Catalogue. Outside manufacturers copied collection objects for review by a Craft Advisory Committee made up of senior administrators, curators, historians, architects, and sales managers. Upon approval, the objects were branded with a registered CW trademark and sold in one of the geographically distributed Craft House Stores. Even the stores conformed to a Colonial Revival design standard by copying the home store in Williamsburg. This tradition continues today in the remaining Craft House Stores, all located in Williamsburg, and through catalogue sales. Only in more recent decades has the emphasis shifted away from the educational mandate and moved toward new marketing strategies, in order to increase revenue for the Foundation in general. This condition reflects a general trend toward specialization not unlike many contemporary corporate structures.

The educational objective is evident in many of the early vendors of Craft House merchandise. One of the earliest vendors was the Kittinger Furniture Company in Buffalo, New York. Life-sized sepia diazo (blueprint-type) prints from the 1940's, now in the CW Archives holdings, illustrate the precision and attention to detail characteristic of these early endeavors. The young furniture collection was selectively copied for sale, and further promoted by the marketing influence of popular demand.

Another example is found in the ceramics of Palin Thorley. The works of this Wedgwood-trained ceramist, now collected in his own right, illustrate the high degree of fidelity sought in copying cream ware in the 1940's and 1950's. Ironically, a former ceramics curator has noted that some of these pieces were conspicuously "better" than their original counterparts—a recurring theme among many different objects of the Colonial Revival period. In his effort to leave his mark, man often improves on the object of inspiration before him. This effect is not unlike individually restored art objects. Restored elements are essentially localized or myopic "reproductions," and are often over-embellished, over-colored, enlarged, or otherwise accentuated by an unconscious human impulse to achieve immortality. Conservators are aware of these phenomena in their daily encounters with restored objects.

Commercial merchandising has advanced in the recent past to include adaptations, loosely categorized as commemorative items. Current featured examples are the Comical Hotch Potch doll, otherwise known as the Alphabet Turned Posture Master and derived from an illustration, the miniature Johannes Spitler decoratively painted chest at one-quarter scale, and the very successful 'water-slide decal' mocha ware.

Endeavors to license and manufacture goods from the 1930's onward paralleled the development of the historic area craftspeople and historic or experimental archaeology as it came to be practiced at Colonial Williamsburg. Trade shops came into being following historical and archaeological research. These shops included the blacksmith, gunsmith, silversmith and brass founder, cabinetmaker and others. This experimental archaeology dovetailed with a burgeoning desire for an artistic satisfaction akin to the arts and crafts revival at the turn of the twentieth century, and was further reinforced by the artistic revival of the 1970's. Although the emphasis of these trade shops is on preserving the period technology of manufacture, they nonetheless result in reproduction objects that may reflect the highest achievement of truly workmanlike goods.

Clearly these varying aspects of reproductions are central to the practice of interpreting a living history museum such as Colonial Williamsburg. Conservators, collaborating with curators, routinely play a vital role in interpreting objects whether in the actual making, patination, and maintenance of reproductions, molding and casting for licensed vendors, educating the public through museum exhibits or lectures on period technology, or in the conservation treatments of collection objects. In fact, the collection would seem to include the reproductions following a literal translation of the museum's stated mission, "That the Future May Learn from the Past." It has been argued that making and maintaining reproductions is itself a preservation activity by the fact that they allow the removal of period objects from vulnerable environments.

In the Department of Collections and Conservation, reproductions are routinely accessioned if they are deemed valuable, based on their initial cost, interpretive value, and on the copied objects's value in the collection. The making of furniture in particular ranges from hand-made objects using period or reproduction tools and techniques, to outside contracts for objects to fill gaps in historic house inventories, to objects manufactured by licensed companies for catalogue sales. Conservators are regularly charged to collaborate on the design, making, patination and subsequent maintenance of a variety of objects. Currently, the furniture laboratory is host to a full-time volunteer cabinetmaker.

Ultimately, treating reproductions—whether in the making and/or maintaining them—depends upon their use in fulfilling the mission of the museum. An ongoing goal is to strike a balance between the historic interpretation work incorporating reproductions, and the larger body of object–specific research and treatment of period artifacts. Ideally, reproductions, whether like the tea towel or the reconstructed Capitol, embody a dual purpose toward a common museum goal. Colonial Williamsburg strives to accurately portray eighteenth century life based on careful and thorough research, tells the stories of the American colonial heritage, and exhibits and publishes period collections for the instruction of the general public. In the historic village one can step up to a Newport chest of drawers in the Dewitt Wallace Museum, and then stroll through the historic area to see a chest of drawers being crafted in the Anthony Hay Cabinet Shop. Finally, one can stroll home in eighteenth century shoes from the Prentis Store for mere sum of one hundred and ninety-five dollars.

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SITTING ON HISTORY: CONSERVATION AND REPRODUCTION OF 19TH CENTURY AUDITORIUM SEATS

Daniel Kurtz, Thomas L. Heller and Susan Glassman

Introduction and Background

How do you go about conserving objects when their physical context and setting within a historic framework are as important as the artifacts themselves? This is the central problem in approaching conservation at the Wagner Free Institute of Science, and the challenge presented to every conservator who works there.

Founded in 1855 and occupying its original Civil War-era building, the Wagner Free Institute of Science is perhaps the best-preserved example of a Victorian natural history museum in this country. It is a rare case where everything - from the collections and furnishings to the exhibit

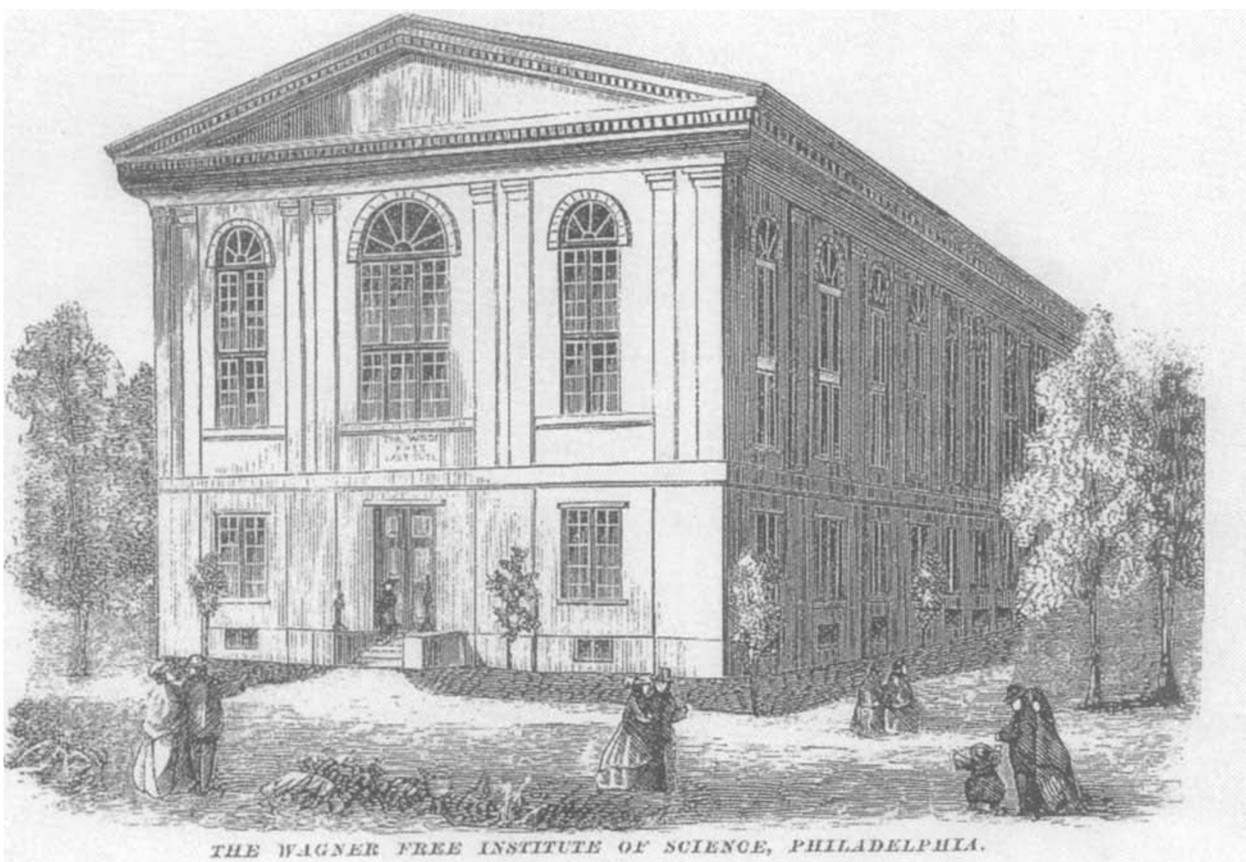

Figure 1. The Wagner Free Institute of Science, at the opening of the building in 1865.

arrangement and the building itself - has survived as an unaltered ensemble from the end of the 19th century. In the skylighted exhibit hall, every aspect of the original display remains in place, from the wood cabinets to the hand-written labels prepared by the museum's first curator.

Like many museums of the period, the Wagner Free Institute of Science began as the vision of a single individual, William Wagner[1]. Born in 1796 to a prosperous Philadelphia family, Wagner was from his boyhood an avid naturalist and collector. Although he spent three decades as a businessman, he devoted all of his free time to his scientific interests. His apprenticeship as a youth to Stephen Girard, the great Philadelphia merchant and financier, gave him the opportunity to collect specimens from places as remote as India and China, where he traveled as an agent on Girard's trading ships. By the early 1840s when he settled with his new wife Louisa Binney on an estate just north of the city, he had a collection sufficiently large to merit building a structure to house and display it.

Wagner was not interested in amassing material solely for his personal enjoyment. His goal was to make scientific knowledge and emerging ideas about the natural world available to anyone, particularly those in "the working classes"[2], whose opportunities for scientific education were extremely limited. In this Wagner mirrored his time, and the enormous growth in the first half of the century of educational institutions of all types. It also reflects the influence of Girard, who left his personal fortune to found a school for orphaned boys.

The educational programs of the Institute began as informal talks given by Wagner on the subjects he knew best: geology, paleontology, mineralogy, and malacology (shells). In 1855, Wagner applied to the state for a charter and hired a faculty to expand the course offerings to include the full range of the sciences, as well as lectures on architecture, and for a time, elocution. From the inception, the courses were held in the evenings to allow working men and women to attend, and were open to all without fees for admission. The lecture series, now in its 145th year, is the oldest program devoted to free adult education in the United States.

The educational programs and Wagner's collections are housed in the building he erected for them between 1859 and 1865. It contains three principal spaces, a lecture hall and library on the ground story, and a soaring exhibit hall that occupies the entire upper level of the building and rises to the exposed trusses of the arched roof. The interior finishes, and the museum display itself, are the result of renovations undertaken by the Institute in the 1880s under the auspices of some of the country's leading scientists. Most notably Dr. Joseph Leidy, a biologist of international importance, expanded the collections and oversaw the installation of a "systematic" arrangement of the specimens. The display, with its glass and wood cases and taxonomic organization, is a unique survivor of a system that was the standard for its day, but which has long since been replaced in nearly all museums.

The Institute's lecture hall was built to serve the free education mission and renovated along with the museum in the 1880s and 1890s. The current seats were installed in 1895, according to a receipt in the Institute's archives. It records that 500 "Concert Hall" seats were purchased for $200.[3] The origin of the seats was the Philadelphia Concert Hall, which was erected in 1852 and opened the following year for concerts, lectures and other entertainments. The Concert Hall was the site of Charles Dickens' public readings in 1868 but by 1890 it had closed as an entertainment venue and in 1895 was altered to house the Main Branch of Philadelphia's new Free Library.[4] The seats were then sold to the Wagner Free Institute of Science and installed in its lecture hall, where they have been in daily use for the past 105 years.[5]

The lecture hall remains the primary location for the Institute's educational programs. While the Institute still offers free science courses for adults, the heaviest use of the lecture hall is for programs that serve children. It is rare that the room is filled for a program but a century of heavy use has nonetheless taken its toll, especially on the seats in the center section. The curved, laminated construction of the seat bottoms makes them particularly vulnerable to wear (there are numerous "historic" repairs) and several years ago we began to formulate a plan to address the problems.

In a historic house the approach to conservation and preservation is clear. Furnishings and interior spaces are cordoned off; active use of objects is eliminated or, at least, severely curtailed. But the Wagner is not a historic house and the goal is to maintain and preserve the collections in situ, including the furnishings, building and the delicate interrelationship of the parts, while continuing to use it as an active museum and educational institution.

Over the past ten years, the Board and staff have worked together with a team of conservators, architects, engineers and various collection specialists, to develop a systematic, long-range plan that will preserve the Institute as a living piece of history. It was designated as a National Historic Landmark in 1990 and work is proceeding slowly and cautiously on its conservation, with the goal of retaining and preserving as much original fabric as possible. In 1992 the Institute completed conservation surveys of the building and collections through the Conservation Assessment Program of the National Institute for the Conservation of Cultural Property (now Heritage Preservation).[6] In 1995 and 1996, an architectural master plan and a comprehensive conservation plan were completed. Implementation of these plans is now in its initial stages.

The approach to the work in the auditorium included replication of seats as a matter of necessity. A number had already failed and been replaced with poor quality replicas, and others were beyond repair. The recommendation in the collection component of our CAP report, completed by Catharine Hawks who serves as an ongoing consultant on collection conservation, was to replace the seats in the area of heaviest wear and tear - the front rows of the center section - with high quality replicas and to preserve the rest, which get much less use.

The Wagner is a singular place in its degree of historic integrity and in continuing to serve its original mission. But what makes it truly special is that it is not simply an artifact of the past. Its continuing appeal is evident in the reactions of visitors. Children particularly love it. They experience the richness of the museum and its collections directly, not filtered through the marvelous but distancing recognition that the Institute is a survivor from another era. They see what one of them called "stones and bones and scientific wonders," things that many of them might not otherwise encounter. For them it is alive with meaning, and that meaning is conveyed not only in the contents of building, but in its arrangement, which offers a direct physical encounter with the tangible world of 19th century science. And in a world of images and ideas, such tangible evidence is all the more powerful.

Figure 2. William Wagner (1796-1185), founder of the Institute

Figure 3. The Institute's exhibit hall occupies the entire upper level of the building and is circled by a U-shaped gallery. Photograph courtesy of Tom Crane.

Figure 4. A view of the lecture hall from the demonstration table. Photograph courtesy of Tom Crane.

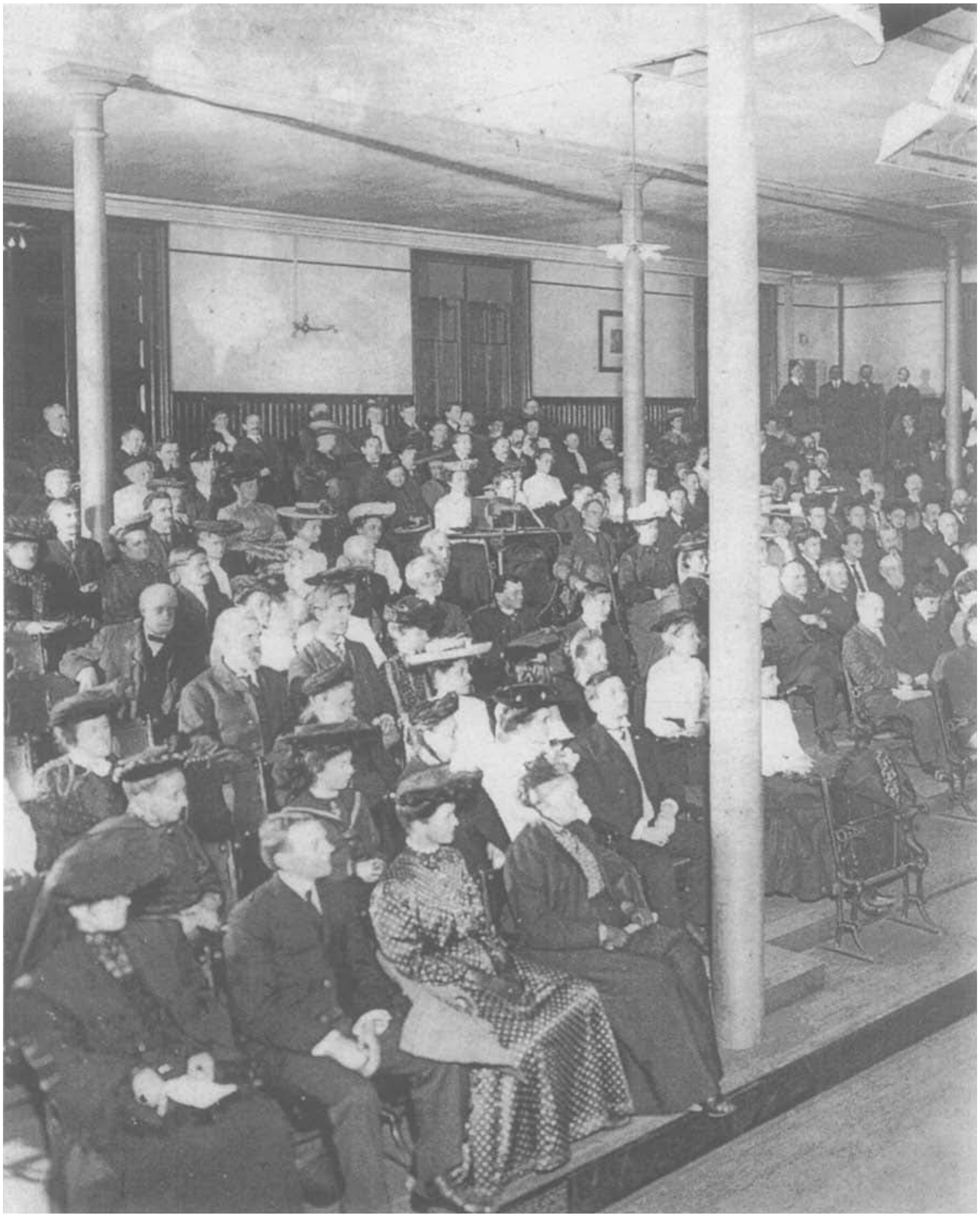

Figure 5. An evening lecture program at the Institute, circa 1905.

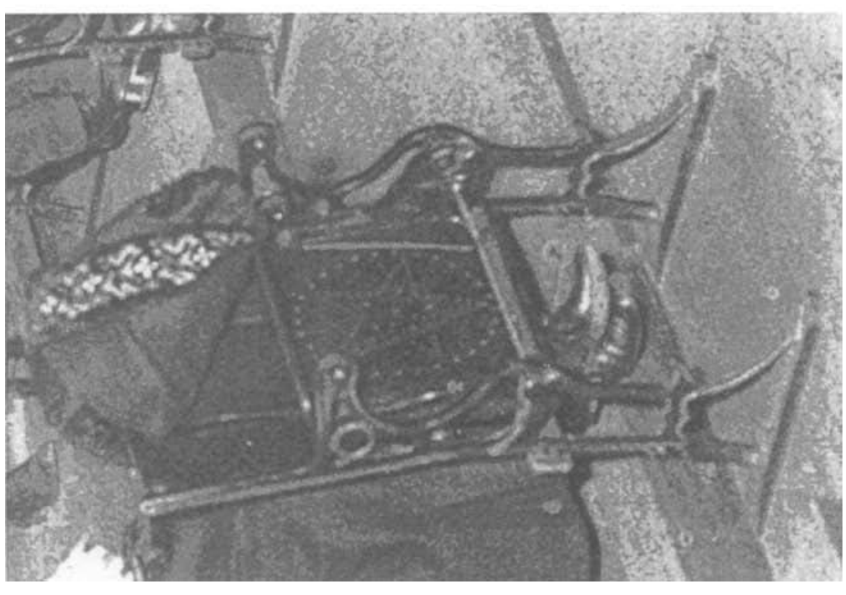

Figure 6. Detail of the seats, from the c.1905 view.

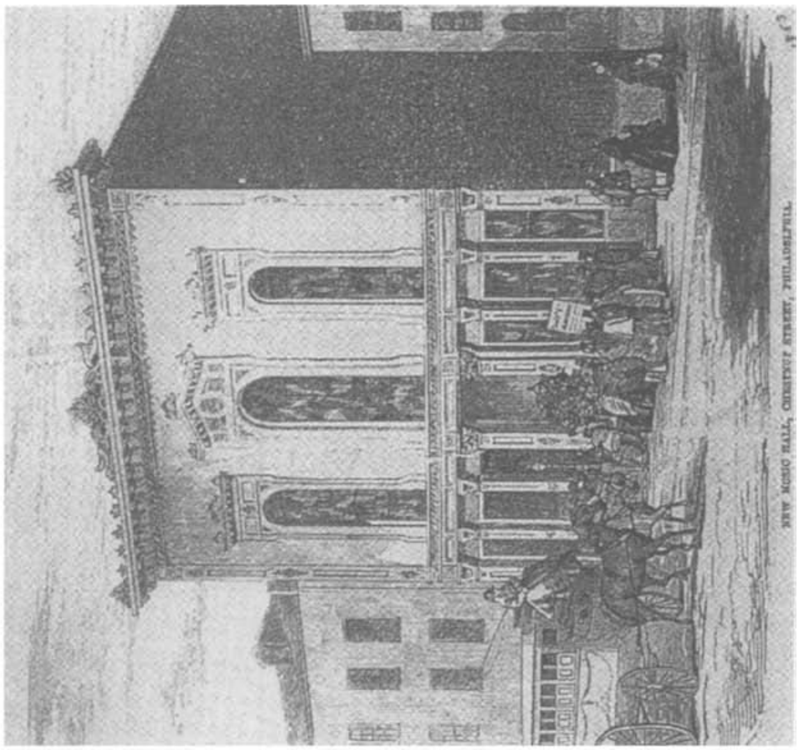

Figure 7. The concert hall in 1853. This illustration appeared in Barnum's Illustrated News soon after the building opened.

Conservation

A major aspect of the conservation plan for the auditorium seats at the Wagner was the treatment of the original seats. The total number of seats to be treated and the continuing use of the auditorium, throughout the duration of the project and in the future, impacted our choice of methods and materials as well as requiring an organized approach to the project. At all times, there had to be enough seats in the sections of the auditorium that get the most use to accommodate the ongoing programs at the Wagner. At the same time, enough of the seats needed to be at the LCA facility to be treated efficiently in order to complete the entire project by the Grant deadline. There are a total of 476 seat openings in the auditorium, each of which required a minimum of a thorough cleaning, touch-up, and waxing.

Figure 8. A view of the auditorium from the entrance.

Examination

Lexington Conservation examined the auditorium seats in August 1998 and prepared a treatment proposal for submission by the Institute as part of a grant application for a two-year Keystone Historic Preservation grant from the Pennsylvania Historical and Museum Commission. The grant was awarded to the Wagner and work began in August of 1999.

Construction

The auditorium chairs are made of cast iron sections that form the arms and seat/back supports of the chairs. These supports are screwed to the auditorium floor. The backs and seats each attach with four screws, with grommets, and nuts to secure the assembly. The backs are made of a top and bottom cross piece with three separate splats and the seat decks are made of five plys of veneer with a complex bent contour. A pattern of decorative air holes is drilled through the seat in the shape of a star inside of a circle. There is a metal wire hat rack attached to the under side of the seats with wooden battens at the back to make the seats more rigid. There are also two wooden rails along the back of the assembly that appear to serve as foot rests for the row behind. Several campaigns of repairs to the seats are evident. The earliest repairs were made by padding the seats with a thin layer of cotton batting covered with black oilcloth attached to the seat top with brass tacks. There are remnants of paper in the surface of some of these sections of oilcloth (an artifact of manufacture) including a section of a calendar dated 1922. There were some later repairs executed using a vinyl cloth over batting that was wrapped over the seat edges and tacked underneath. Several of the seats had a self- adhesive "contact" paper on the top surface. There were also a number of modern seat replacements, circa 1980's. During the examination phase, it was determined that there were, in fact, two different sizes of seats – a 19 inch wide variety and an 18 inch wide variety. It is unclear why this is the case, as the seats are scattered randomly throughout the auditorium.

Surface Appearance

The iron supports are painted black, with some rows having details highlighted in gold. The wooden elements are stained a semi-opaque red/brown color and are coated with a semi-clear varnish. The varnish fluoresces a yellow-green when examined under longwave ultraviolet examination, characteristic of a natural resin varnish. Some of the chair backs have letters painted on them in a gold paint. These letters are upper case and approximately 4" in height. The chairs with these letters are scattered randomly around the auditorium, and most likely relate to the previous installation of these chairs in the Concert Hall on Chestnut Street.

Condition Summary

The chairs were generally stable overall considering their age and the amount of use they receive. The main area of concern was the seat decks, which varied considerably in condition, ranging from cosmetic problems to seats that were completely missing.

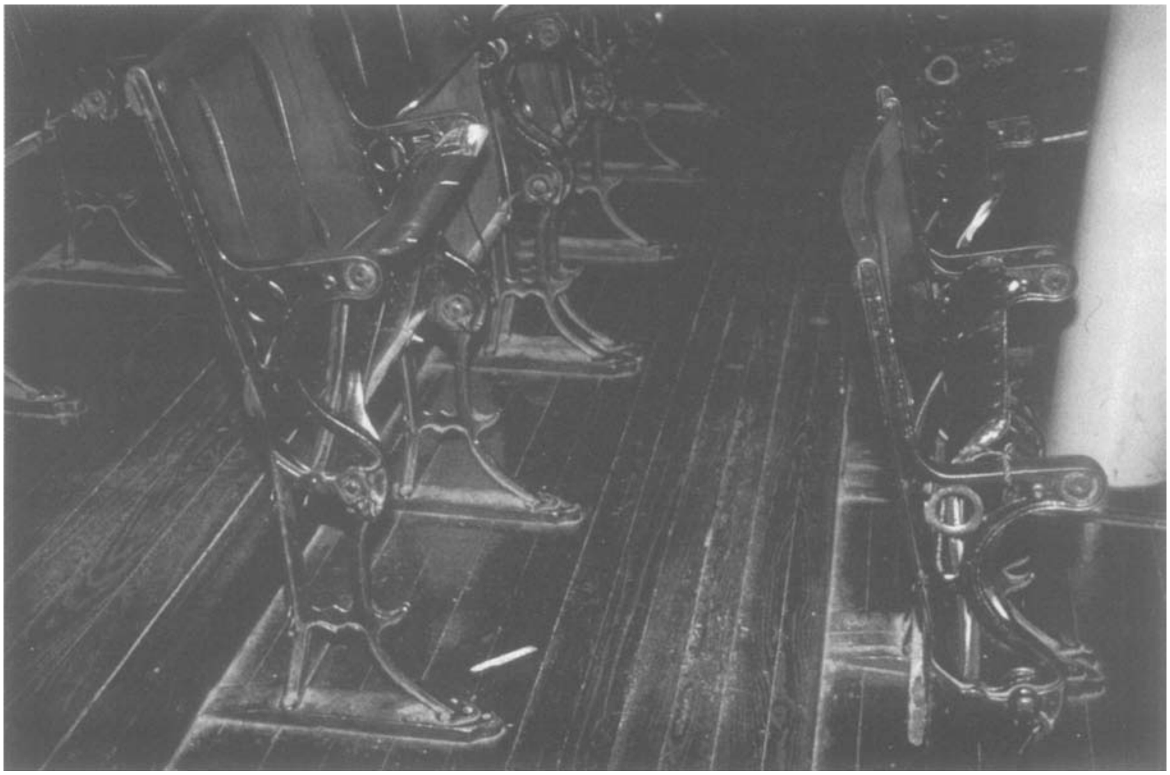

Figure 9. Detail of chairs in the auditorium

Structure

As mentioned, the chairs were in varying states of structural repair, especially the seats. The iron supports and the backrests were generally stable. The following six condition categories were established to describe the original seats.

Category 1: Minor cosmetic work needed. These seats were determined to have no structural problems. The main concern with these seats was the dirt and grime on the surface and other cosmetic problems such as chewing gum and scratches in the finish.

Category 2: Minor veneer repair needed. These seats had small losses (less than 2" x 2" in size covering no more than 15% of the total surface area) to the outer veneer layer on either the top or bottom of the seat.

Category 3: Major veneer repair/minor structural repair needed. These seats had large losses (more than 2" x 2" in size covering no more than 60% of the total surface area) to the outer veneer layer on either the top or bottom of the seat and/or areas of delamination of the veneer layers.

Category 4: Major structural work needed/unrepairable. These seats had one or more of the following problems: loss of more than 60% of the outer veneer layer on either the top or bottom of the seat, significant delamination of the veneer layers, loss of large sections of the seat (such as the corners), large complex breaks running through all the veneer layers compromising the structural integrity of the seats.

Category 5: Missing seats. These seats were completely missing or had been previously deinstalled due to significant structural damage.

Category 6: Modern seat. These seats were modern (circa 1980's) plywood replacement. They were reasonable approximations of the original seats; however, they were not as sturdy, were slightly larger, had a different surface appearance, and did not have the decorative pattern of holes drilled in them.

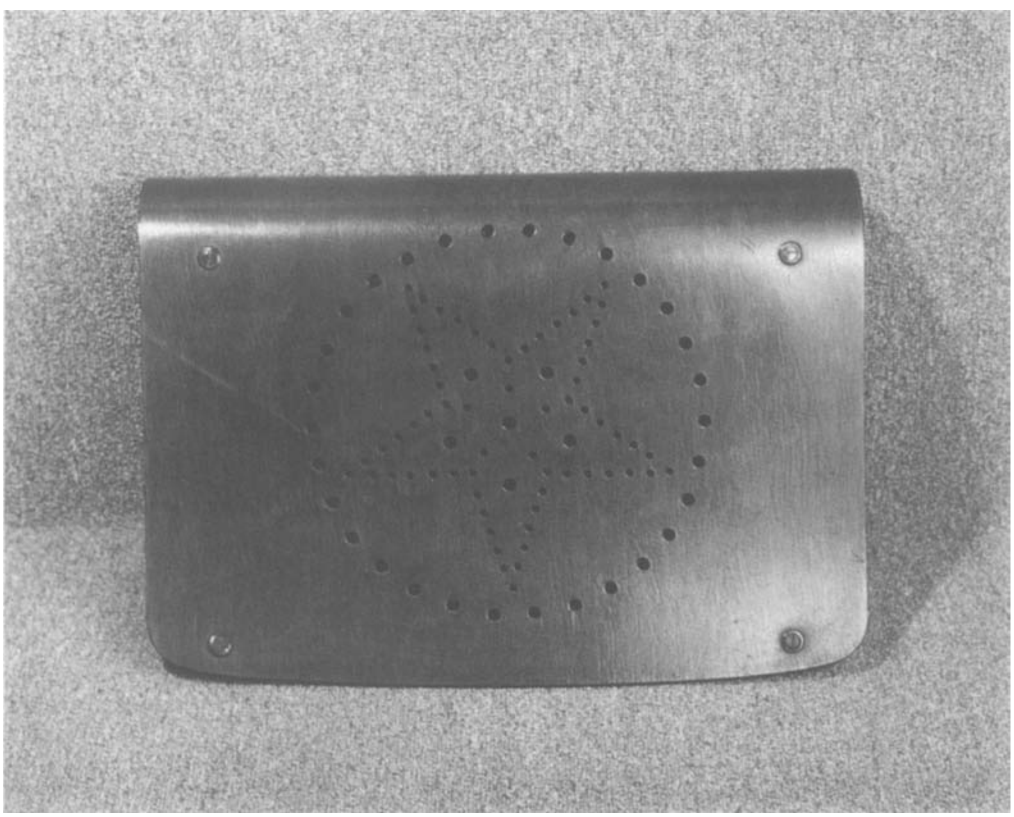

Figure 10. Category 1 seat: minor cosmetic work needed.

Figure 11. Category 2 seat: minor veneer repair needed.

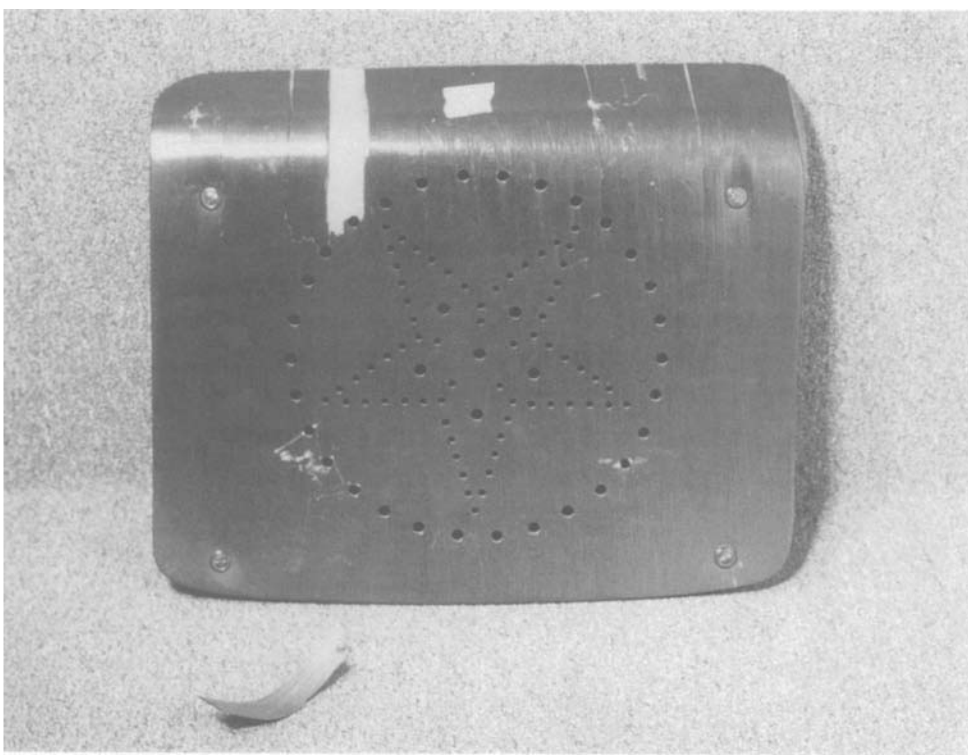

Figure 12. Category 3 seat: major veneer repair/minor structural repair needed.

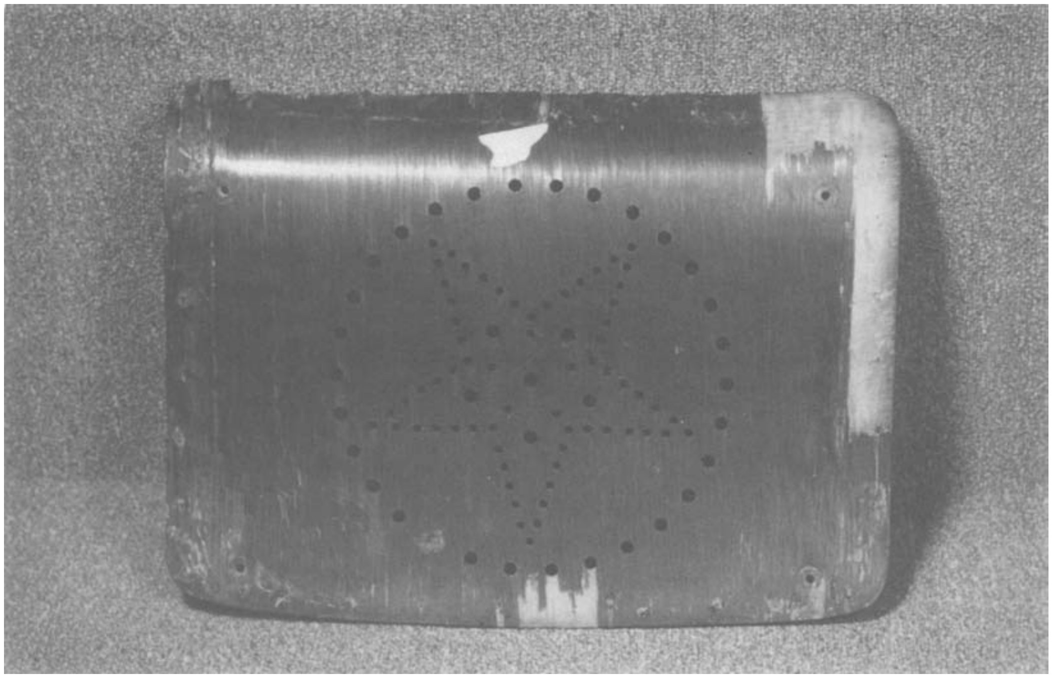

Figure 13. Category 4 seat: major veneer/minor structural repair needed.

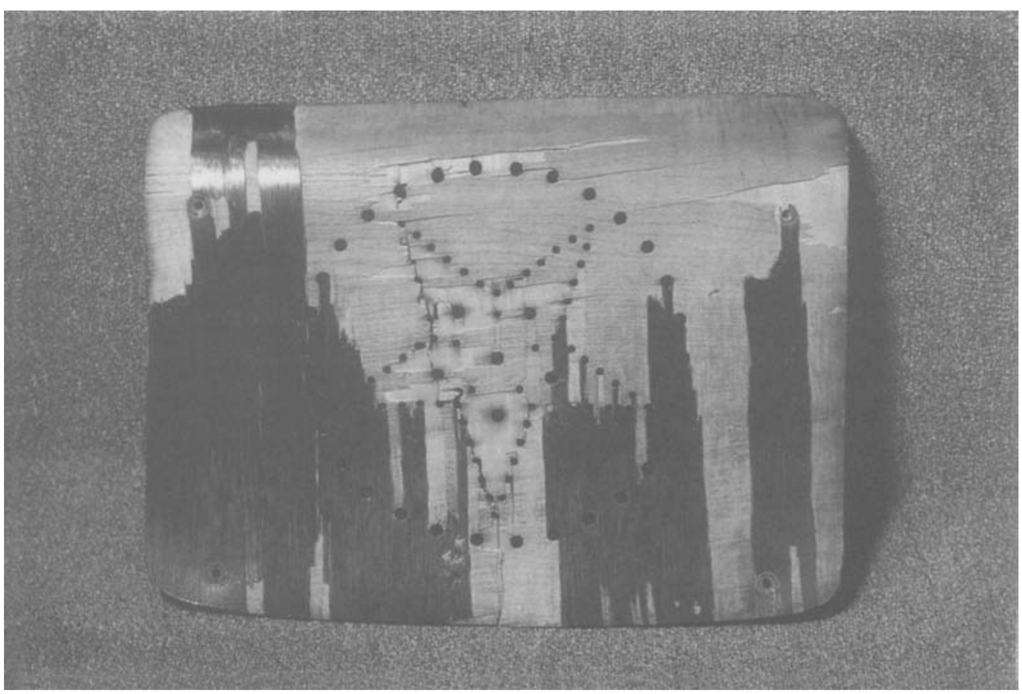

Figure 14: Category 4 seat: unrepairable.

There were some additional structural concerns with the auditorium seating including the following: approximately 75 missing or broken battens under the seats at the rear, 1 missing back assembly, and several missing or broken "foot rests."

Surface Condition

There was a layer of dirt and grime on the chairs overall. The paint on the iron supports was abraded and worn unevenly overall. The finish on the wooden elements had darkened but had an overall even appearance under normal illumination. When examined under longwave ultraviolet light it becomes apparent that where the coating is more exposed to light it is more degraded.

Treatment Goals

General: The seats represent an integral part of the institution overall. The Wagner Free Institute Long Range Conservation Plan, updated June 1996 points out the importance of treating objects such as these chairs. It reads, "Originally not included in the accessioned and documented collections, the original furnishings, fixtures, and cabinetry in the building are now included as an important part of the collection because they are the physical embodiment, along with the collections, of this unique nineteenth-century scientific and educational institution...Therefore, conservation of the institutional integrity is as important as conservation of individual specimens or collections of specimens." Treatment of the auditorium chairs represented an important step in achieving the goals set forth by the institution.

Specific: The main goal of the treatment was to address the structural concerns of the seats. Some degree of cosmetic work was desired to improve the overall appearance of the seats without doing a complete restoration.

Treatment

A graphic chart of the auditorium was created and each seat labeled with a three-digit code. These codes indicated the section, row, and seat number. As seats were deinstalled they were labeled with this code. In most cases, the seats were replaced in the same location from which they were removed. The exception was the seats in the two sections of the auditorium that receive the most use. Initially, the original seats in this area were removed and replaced with the existing modern replacements and seats with old repairs (second campaign covers on the surface). This was done to minimize additional damage to seats that were to be conserved. After conservation, the period seats were reinstalled in other areas of the auditorium and the new reproductions placed in the high use areas.

The seats were deinstalled in groups of 30 to 50. A drop of penetrating oil was put on the threads of each of the four screws to help break the nut free and make them functional. A cordless drill/driver with a 12 mm, 12-point socket bit was used to speed up the deinstallation process, and it was found that approximately 10 seats could be removed per hour, per person. Reinstallation was a slower process, with an average of only 6 seats per hour, per person.

After the seats were deinstalled they were taken to the LCA facility where they were generally sorted by category and then treated.

Category 1 seats were surface cleaned with a dilute mild detergent in water and/or degreased with solvent as needed. Losses to the finish were touched up with Blendal Powder Stain extra fine ground dry pigments in Behlen's A.C. Garnet Shellac, 1 ½ pound cut in denatured alcohol. A light pad application of shellac was applied to the surface to even out the gloss overall. The seats were waxed with Behlen's Blue Label brown Paste Wax and buffed to an appropriate gloss.

Category 2 seats were surface cleaned with a dilute mild detergent in water and/or degreased with solvent as needed. Any areas of loosed/delaminating veneer were consolidated by injecting hot hide glue with a syringe and clamping until set. The losses in the veneer were filled in two manners. Losses smaller than ¼ inch x ½ inch were filled using Ciba Specialty Chemicals Araldite AV 1253 Carvable Paste. Larger losses were filled using patches of birch veneer chosen to match in grain pattern and type. Veneer patches were inpainted/infinished using a combination of materials including: Blendal Powder Stain extra fine ground dry pigments in Behlen's A.C. Garnet Shellac, 1 ½ pound cut in denatured alcohol; Orasol dyes (Brown 2GL, 2RL, 6RL; Black RLI; Red 3GL, Yellow 2GLN) in shellac; Winsor & Newton water colors; and artist's oil paints. The finish on the fills was built up using shellac. Losses to the finish were touched up with Blendal Powder Stain extra fine ground dry pigments in Behlen's A.C. Garnet Shellac, 1 ½ pound cut in denatured alcohol. A light pad application of shellac was applied to the surface to even out the gloss overall. The seats were waxed with Behlen's Blue Label brown Paste Wax and buffed to an appropriate gloss.

Category 3 seats required more extensive work than those of Category 2 (e.g. larger patches, more consolidation) but the methods and materials were similar. Seats were surface cleaned with a dilute mild detergent in water and/or degreased with solvent as needed. Areas of loosed/delaminating veneer were consolidated by injecting hot hide glue with a syringe and clamping until set. The losses in the veneer were filled in two manners. Losses smaller than ¼ inch x ½ inch were filled using Ciba Specialty Chemicals Araldite AV 1253 Carvable Paste. Larger losses were filled using patches of birch veneer chosen to match in grain pattern and type. Veneer patches were inpainted/infinished using a combination of materials including: Blendal Powder Stain extra fine ground dry pigments in Behlen's A.C. Garnet Shellac, 1 ½ pound cut in denatured alcohol; Orasol dyes (Brown 2GL, 2 RL, 6RL; Black RLI; Red 3GL, Yellow 2GLN) in shellac; Winsor & Newton water colors; and artist's oil paints. The finish on the fills was built up using shellac. Losses to the finish were touched up with Blendal Powder Stain extra fine ground dry pigments in Behlen's A.C. Garnet Shellac, 1 ½ pound cut in denatured alcohol. A light pad application of shellac was applied to the surface to even out the gloss overall. The seats were waxed with Behlen's Blue Label Paste Wax and buffed to an appropriate gloss.

Category 4 seats presented the largest challenge. Many had extensive structural problems such as large areas of loose surface veneer, and delamination of the inner plys requiring significant repair. The complex curved shape of the seats made it difficult to get the required clamping pressure in all areas. An attempt was made to use a vacuum press (see section on fabrication of new seats for a detailed discussion of the vacuum press set-up) to reglue these seats but the heavy bag did not allow the water in the hide glue to evaporate, keeping it from fully setting and leading to the formation of biological growth. This led to new approaches, including the development of several cauls and clamping methods to consolidate these seats.

The losses in the veneer were filled in two manners. Losses smaller than ¼ inch x ½ inch were filled using Ciba Specialty Chemicals Araldite AV 1253 Carvable Paste. Larger losses were filled using patches of birch veneer chosen to match in grain pattern and type. Veneer patches were inpainted/infinished using a combination of materials including: Blendal Powder Stain extra fine ground dry pigments in Behlen's A.C. Garnet Shellac, 1 ½ pound cut in denatured alcohol; Orasol dyes (Brown 2GL, 2 RL, 6RL; Black RLI; Red 3GL, Yellow 2GLN) in shellac; Winsor & Newton water colors; and artist's oil paints. The finish on the fills was built up using shellac. Losses to the finish were touched up with Blendal Powder Stain extra fine ground dry pigments in Behlen's A.C. Garnet Shellac, 1 ½ pound cut in denatured alcohol. A light pad application of shellac was applied to the surface to even out the gloss overall. The seats were waxed with Behlen's Blue Label brown Paste Wax and buffed to an appropriate gloss.

Figure 15. Seat with historic oilcloth covering, before treatment.

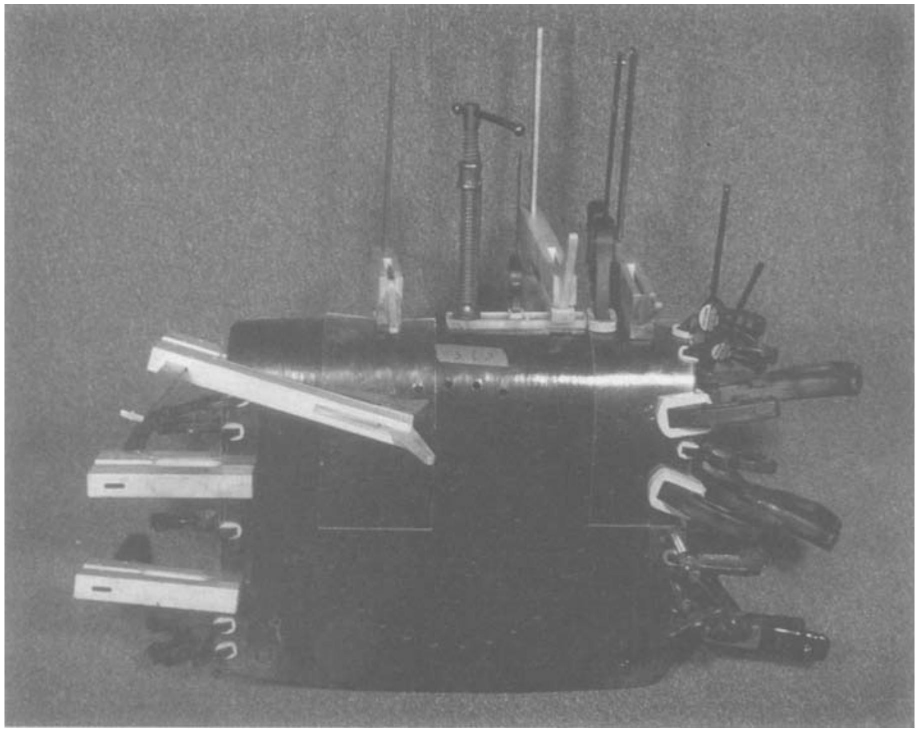

Figure 16. Seat during treatment: consolidation of loose/delaminating veneer.

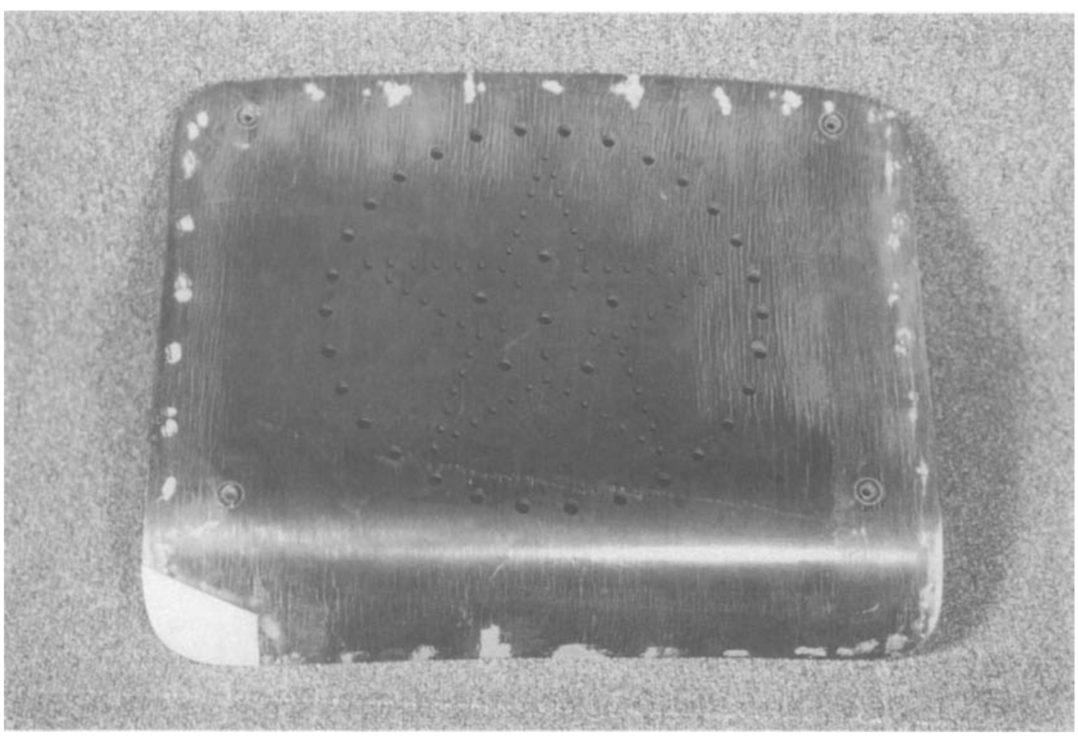

Figure 17. Seat during treatment: veneer and epoxy fills.

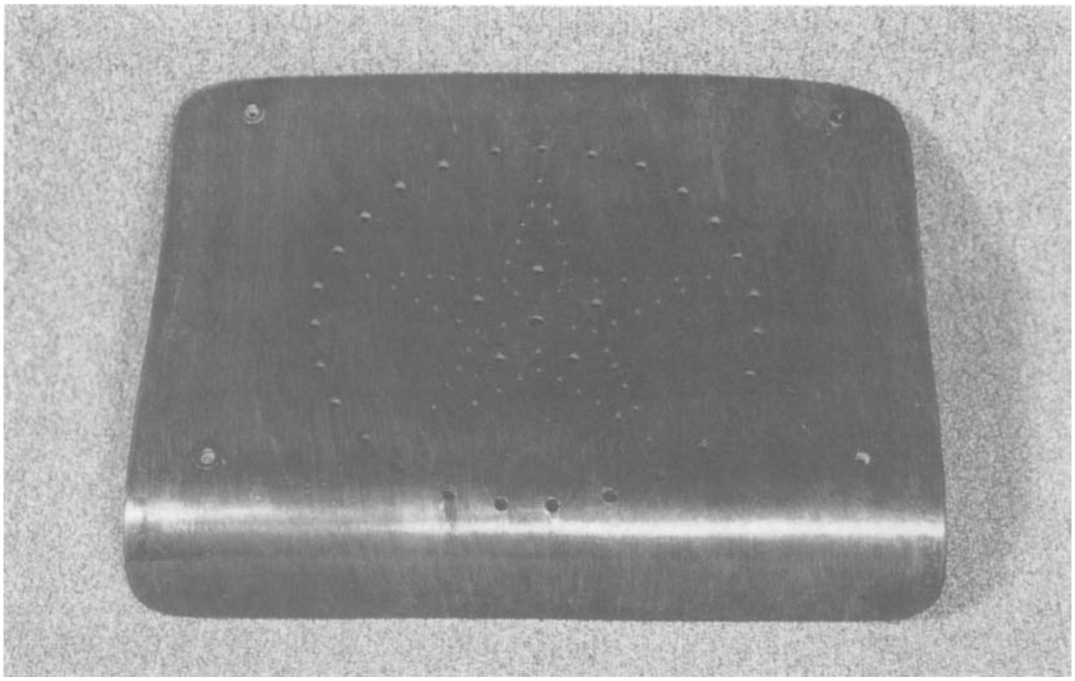

Figure 18. Seat after treatment.

Category 5 & 6 seats were replaced with new reproductions manufactured by LCA as described below.

Replication of Seats

A major portion of the overall auditorium seating project was the replication of approximately 100 seats. The replicas were to match the originals as closely as possible in terms of shape, wood choice, and color. Harry Alden of Alden Identification Service carried out wood identification on a sample of veneer from one of the category 4 seats. It was identified as Birch (*Betula* sp.). In order to better understand the fabrication process, research was undertaken into both the process and history of this technique.

Brief History of Bent Laminated Seating Forms

Samuel Gragg, of Boston Mass., received a patent in 1808 for his 'elastic chair', unlike the Windsor style chair, whose bent components such as the hoops, arm rests, and crest rails are all comprised of individual pieces, Gragg appears to be the first American maker to utilize continuous bent components as primary structure and perhaps even foresaw what was to come? Michael Thonet, by the 1830's, was experimenting with bent laminated components used as chair parts and received a patent in Vienna in 1842. In 1856 John Henry Belter received a patent for a bedstead comprised of laminated veneers. Additional patents in 1858 and 1860 indicate Belter's continuing work with bent laminated forms. In 1872 Gardner and Company of New York received a patent for a platform rocker. Utilizing pierced bent laminated components the work of Gardner appears very similar to the Wagner's auditorium seating. Unfortunately, no attribution can be made regarding the manufacturer of the Wagner's seats, what is clear, however, is the popularity of bent furniture components from the mid nineteenth into the twentieth century.

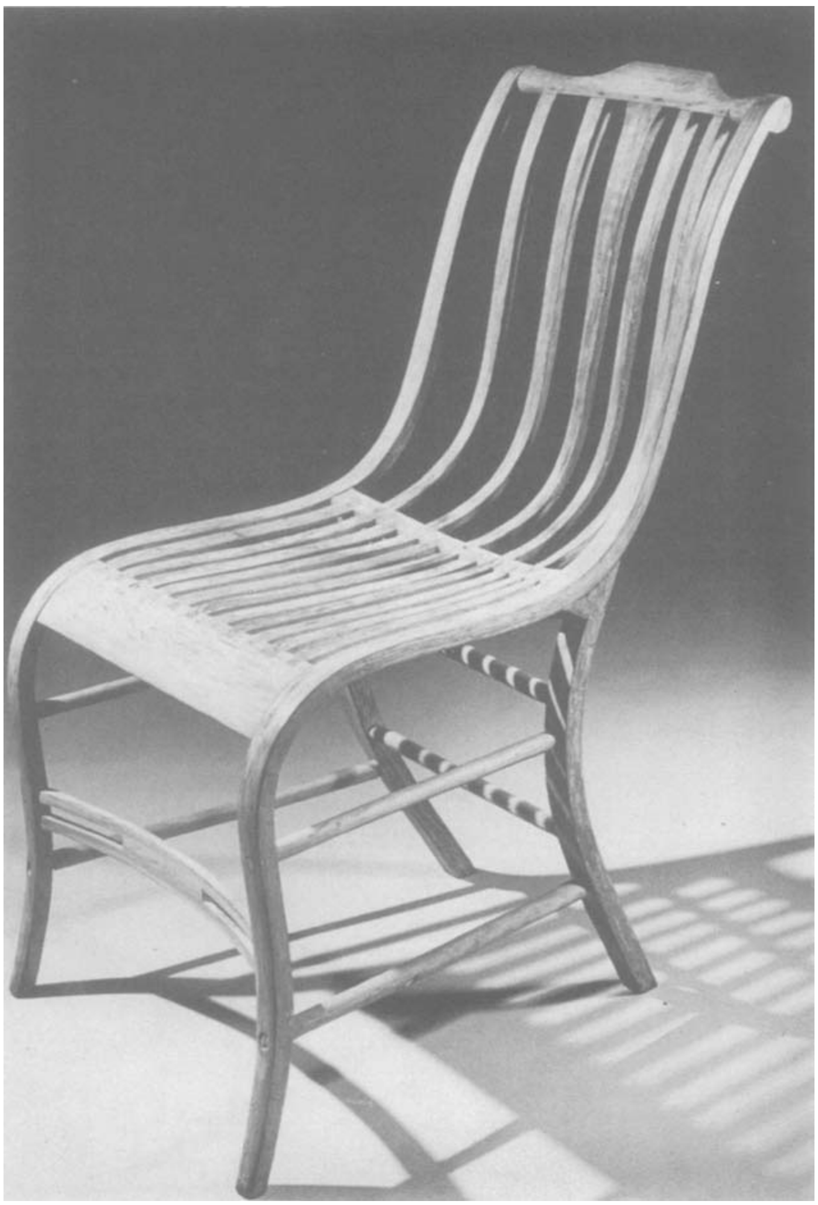

Figure 19. Elastic Chair. Samuel Gragg, Boston, Mass., 1808.

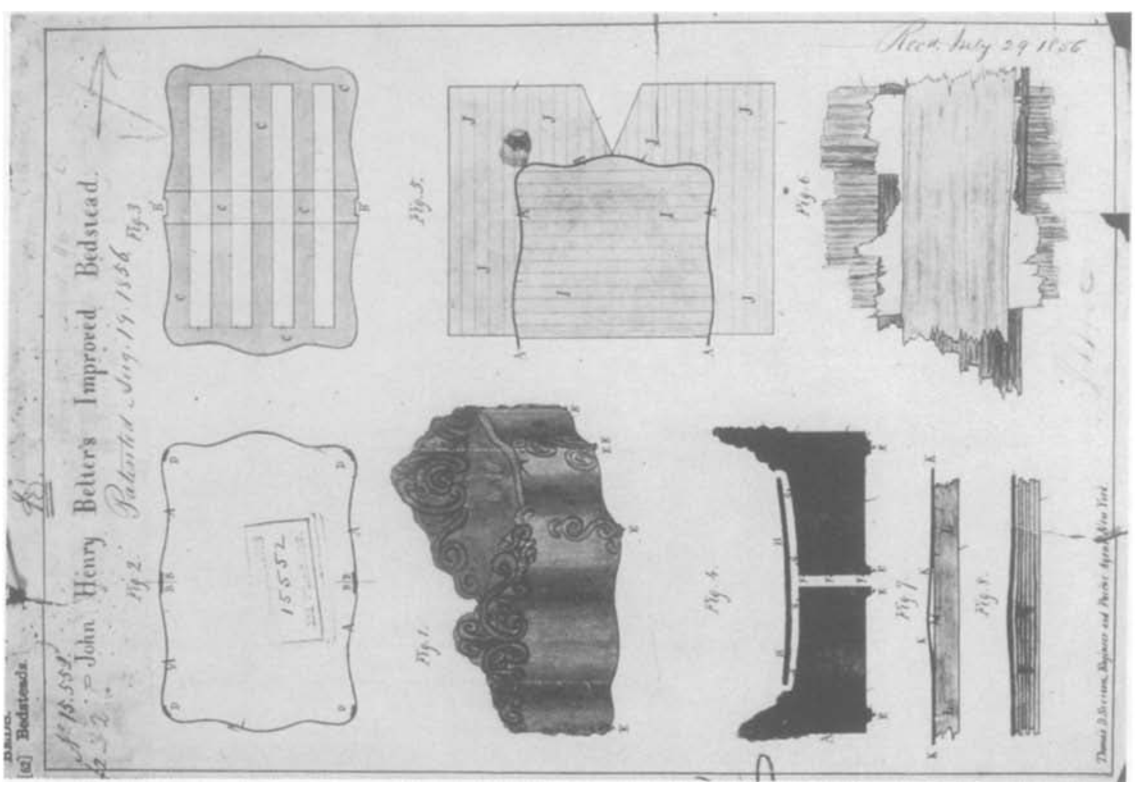

Figure 20. John Henry Belter patent for a bedstead.

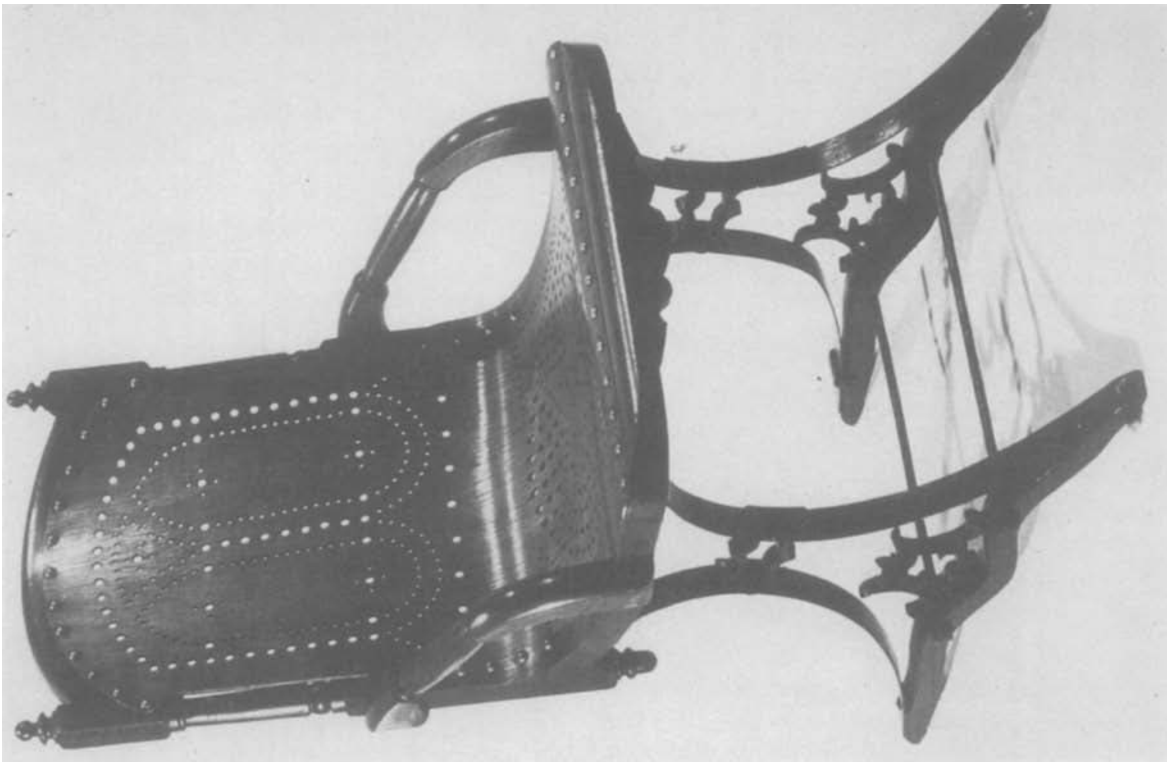

Figure 21. Platform rocker, Gardener and Company, New York, 1872.

Fabrication of replicas

After scouring old issues of Fine Woodworking magazine for articles on bent laminated furniture techniques, we decided upon a system utilizing a vacuum press, which has proven to work out rather nicely. The pump maintains a vacuum of between 21 and 25 inches of mercury, or approximately 1,764 lbs. per square foot and was purchased from Vacuum pressing systems, New Brunswick, Maine. The original seats are comprised of 5 plys and the seats' total thickness is approximately ¼ inch. After much searching, we were fortunate to locate a mill in Canada, Veneer Products of New Brunswick, that was able to supply us with 1/20 of an inch birch veneers. Urea formaldehyde resin glue was chosen as the preferred adhesive for several reasons; budget, stiffness, working properties and the lack of conservation related concerns with this specific application. The original seats were made using hide glue, but prototypes utilizing hide glue proved problematic; the glue gels quickly, water evaporation in the press is very slow and this, no doubt, contributed to the excessive mold formation that was found after removing the prototype from the press. Additionally, urea resin glue will aid in segregating the replicas from the period seats in future years. Although the glue does contain formaldehyde only 0.8 grams of free formaldehyde is present in each seat after the glue cures (90-95% of the formaldehyde is consumed in the curing process), additionally free formaldehyde off-gasses quickly and the seats were not installed until several months after fabrication. The manufacturer, National Casein, conforms to all EPA and OSHA threshold values and formaldehyde is most dangerous when burned or in powder form; therefore respirators were worn while mixing the glue. Additionally, the size of the auditorium and the amount of air exchange (as a result of old leaky nineteenth century double-hung window sash) should negate any possible detrimental effects of the formaldehyde.

The first step in the process was the fabrication of cauls or forms shaped to the necessary profile. Templates for cutting the form section pieces were made with ¼ inch plywood. The profiles were traced onto the 1 inch particle board pieces and then rough cut on the band saw. The templates were then stapled to the roughed particleboard and the profiles are refined with a flush-trim bit and router. Twenty pieces of particle board were prepared in this manner and the individual sections were glued and nailed to comprise a form 20 inches wide.

Our replicas also consist of 5 plys each, as do the original seats. The odd number is necessary for maximum strength; the grain of all plys must be oriented perpendicular to the adjacent ply(s).

Initial experiments attempting to bend straight veneer pieces to the final shape proved unsuccessful, and it was discovered that the individual plys needed to be pre-bent. A jig, that we call the pre-press jig, was devised to accomplish this. The individual plys are soaked briefly, placed in the jig wet, and allowed to dry. After the wood has dried, the plys retain the desired shape and will now nestle nicely onto the bending forms.

The adhesive, mixed 400 grams of resin to 240 grams of water, is spread over the contact surfaces of each ply with a roller as they are laid on the form. Plastic sheeting is carefully placed overtop of the veneer and a section of bendable plywood placed on top as an upper caul. The plastic is to prevent glue contact with the vacuum bag and platen. The forms are placed in the vacuum bag where the laminates will remain, under compression, for at least twelve hours.

The next step requires profiling the corners of the seat and the rear edge of each seat. Another jig, which we refer to as the seat plan jig was designed so that the radiused corners and the curved back edge of the seat could be traced onto the seat blank. The seat is rough cut at the band saw and sanded to the pencil line on a 6" belt finishing machine. Minor irregularities can be corrected with files and sand paper.

After fabrication of several seats, we wondered, "How strong are they?" One seat was taken out to the parking lot and a Subaru station wagon slowly driven over it. The seat withstood the pressure until the full weight of the vehicle was on it. However, only the bottom two plys broke and the seat still retained its shape.

After shaping the seat profile, the pierced seat pattern is created. This is done by marking the pattern onto the seat using a Mylar template taken from an original seat. The holes are then carefully drilled on an extra seat to minimize tear-out.

The last production step before the application of finish is sanding the seat blank with a palm sander and 150 grit paper.

A sealer coat of garnet shellac in ethanol was brushed on to both sides of each seat. The seats were then hand sanded with 220 grit paper. The color was achieved using Orasol dyes applied with a spray system. Two distinct colors, a lighter undertone (Red 3GL, Brown 2GL, Yellow 2GLN Black RLI) and a darker toning layer (Black RLI Red, 3GL) were applied. The seats were then given several applications of garnet shellac as a top coat. The shellac layers were lightly sanded between coats and the final coat steel wooled. The seat surfaces were then waxed.

The completed seats were taken to the Wagner and the necessary holes for mounting the seat to the chair frame were drilled on site. Additionally, the hat rack hardware and rear batten were attached during installation.

Conclusion

After all the seats were conserved/fabricated and installed, a regular maintenance schedule was established. Frequent inspections for new damage are scheduled and rapid repair of any problems is anticipated. The protective wax coating will be updated as needed. It is hoped that this will enable at least another 100 years of programming in this wonderful auditorium

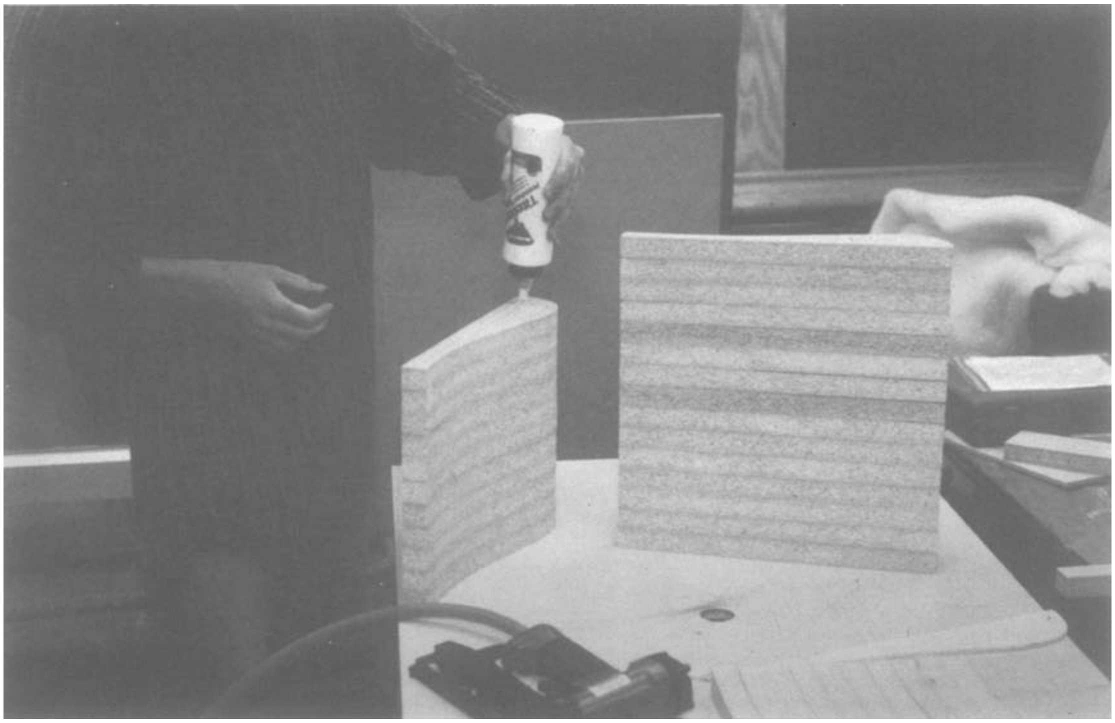

Figure 22. Fabrication of forms.

Figure 23. Soaking veneers.

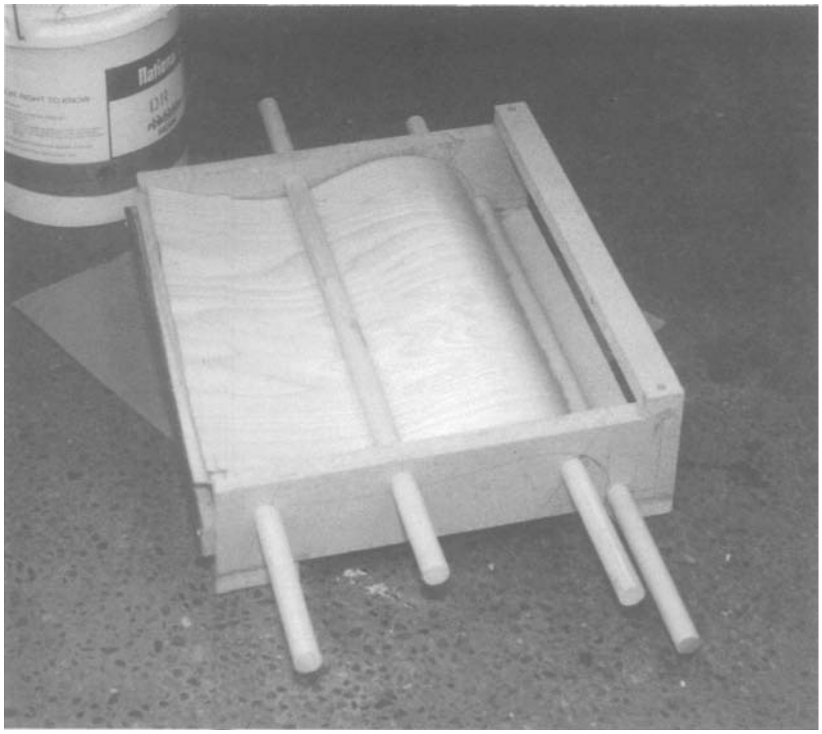

Figure 24. Veneer in pre-bending jig.

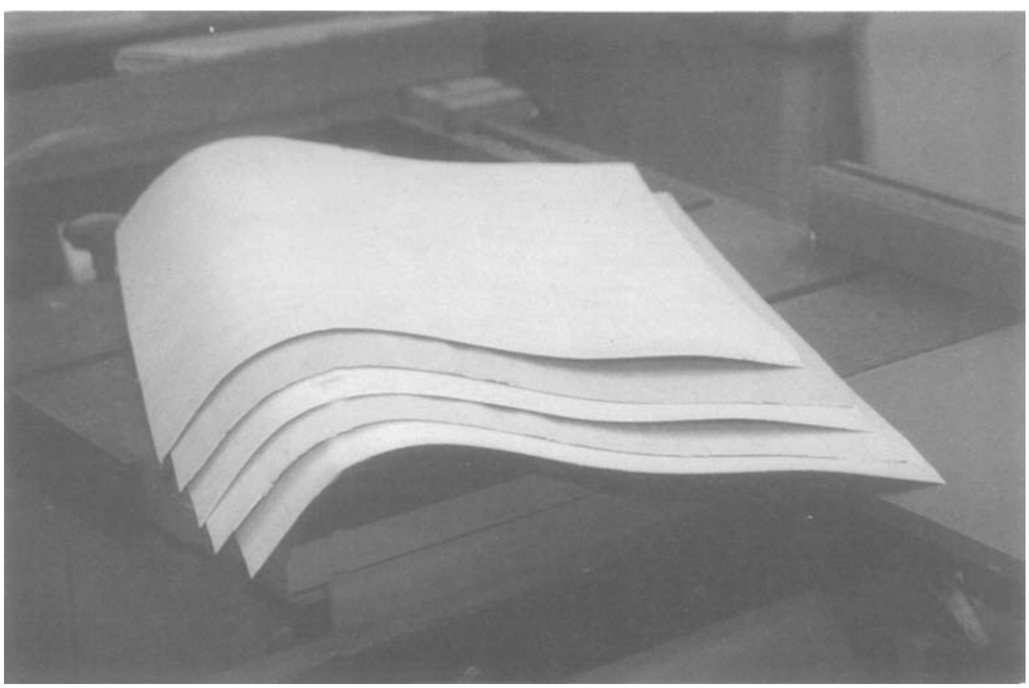

Figure 25. Pre-bent veneers.

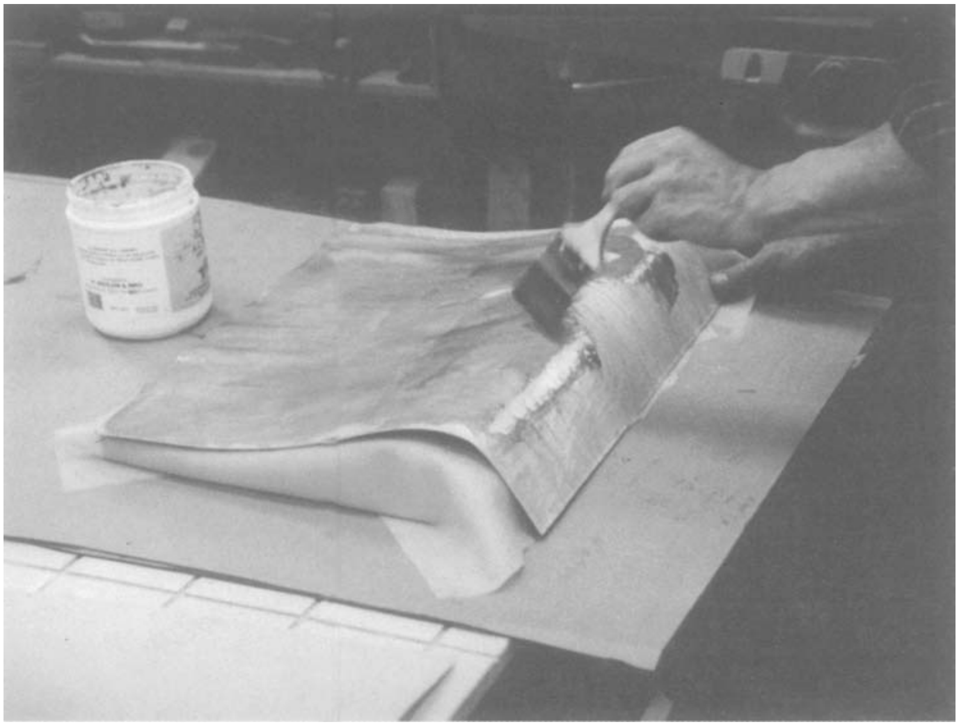

Figure 26. Application of urea-formaldehyde resin adhesive.

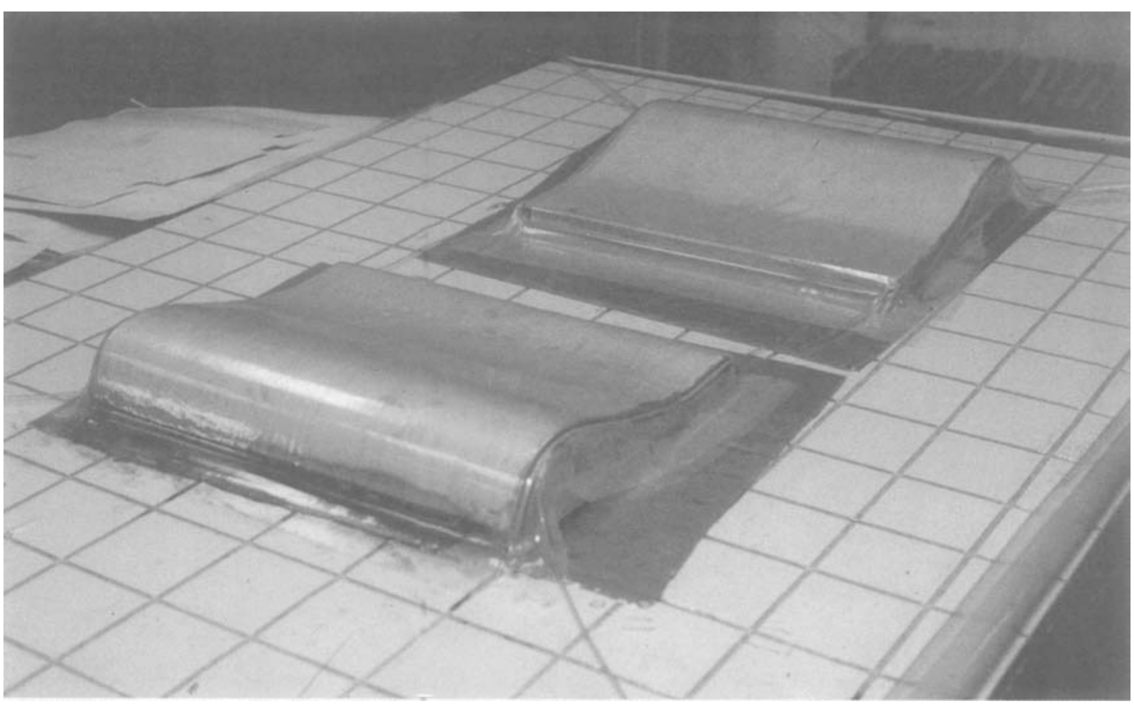

Figure 27. Fabricating seats in the vacuum press.

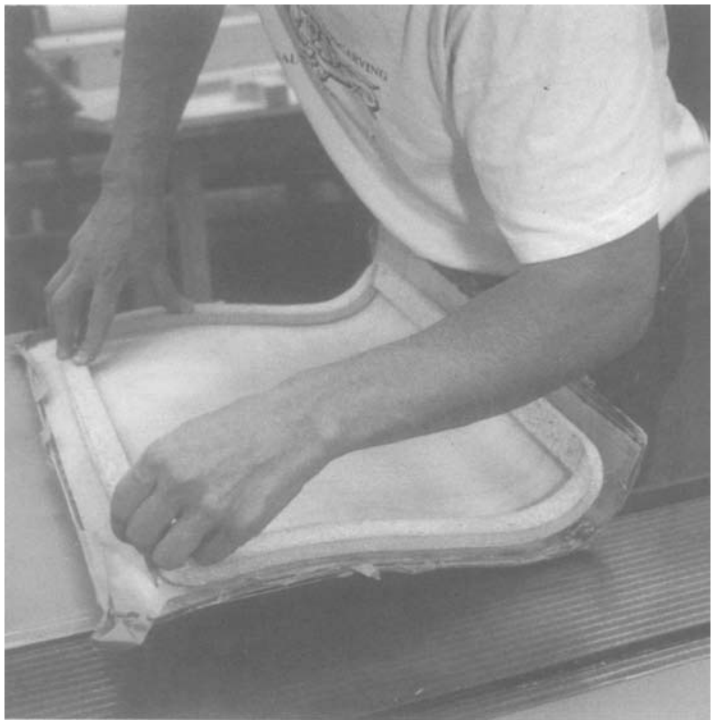

Figure 28. Tracing the seat plan jig on a seat blank.

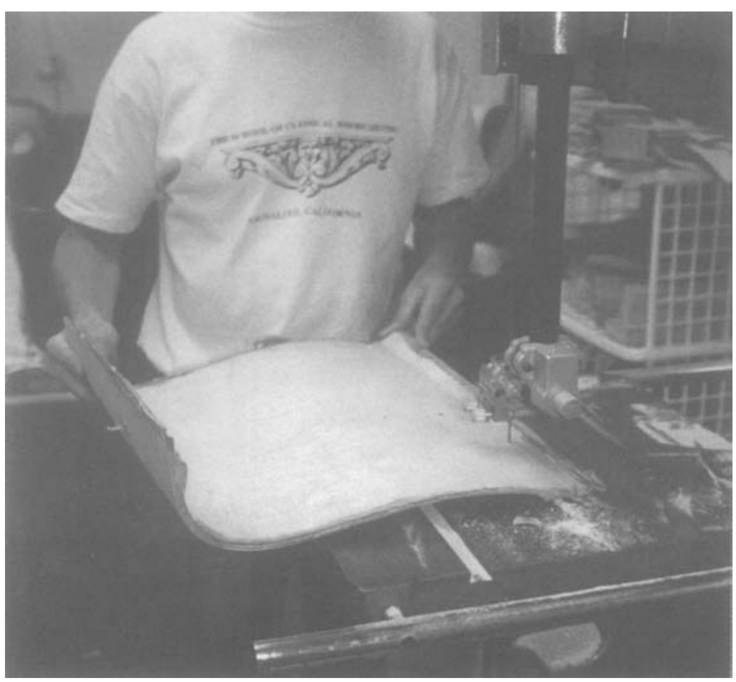

Figure 29. Cutting a seat to shape with a bandsaw.

Figure 30. Sanding a seat to the final shape.

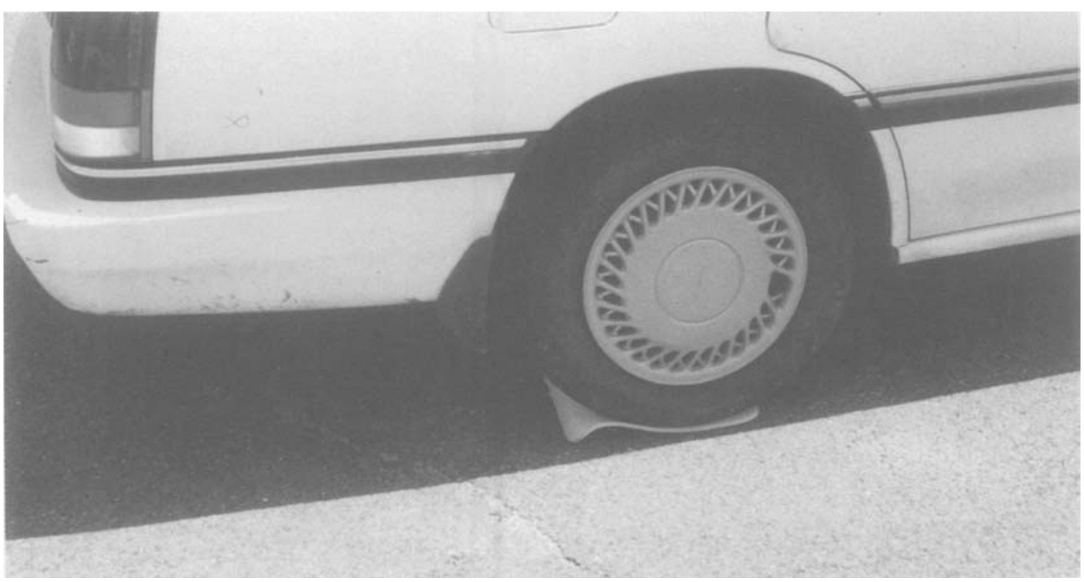

Figure 31. Strength test.

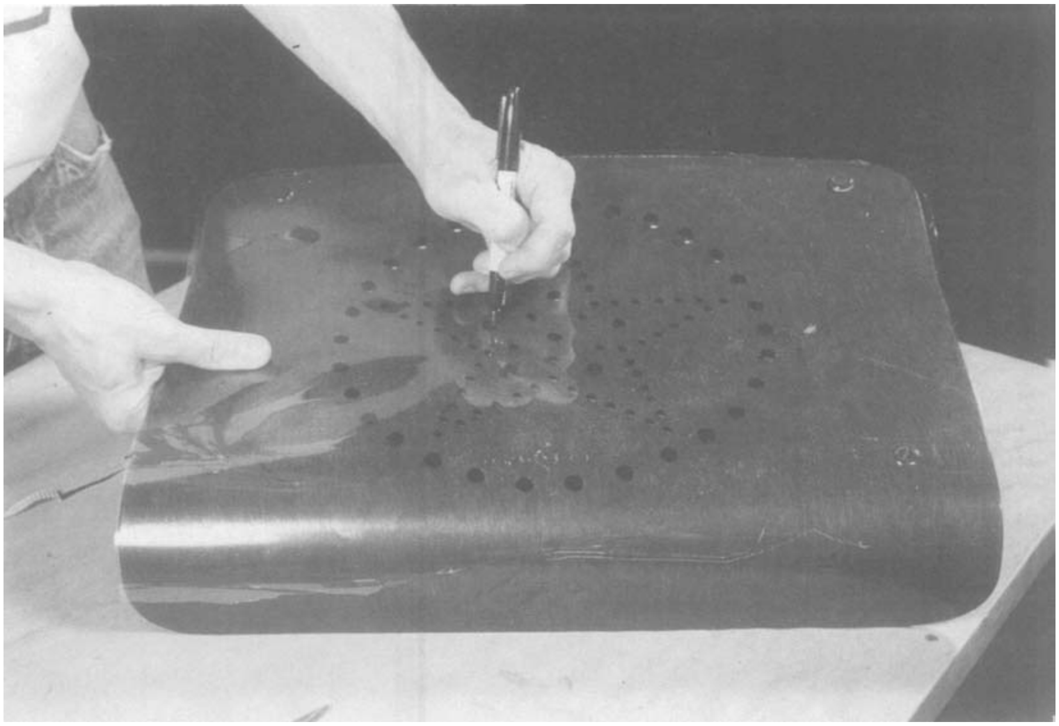

Figure 32. Making a Mylar template for drilling holes.

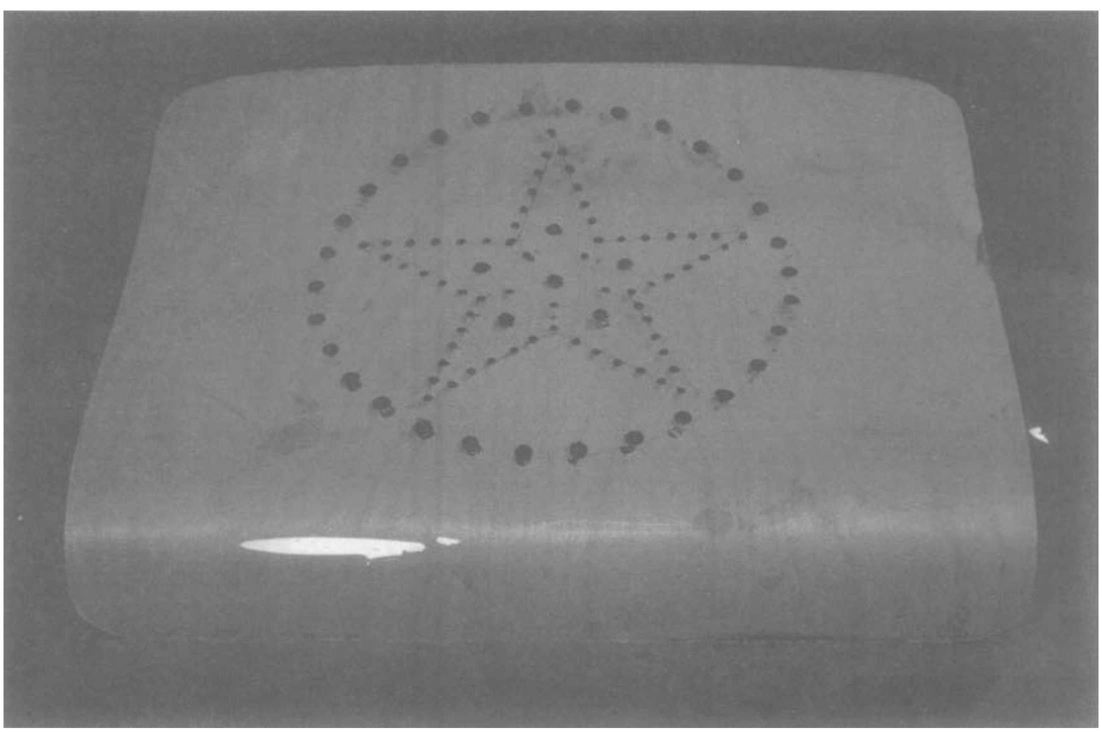

Figure 33. Transferring the hole pattern to a seat blank.

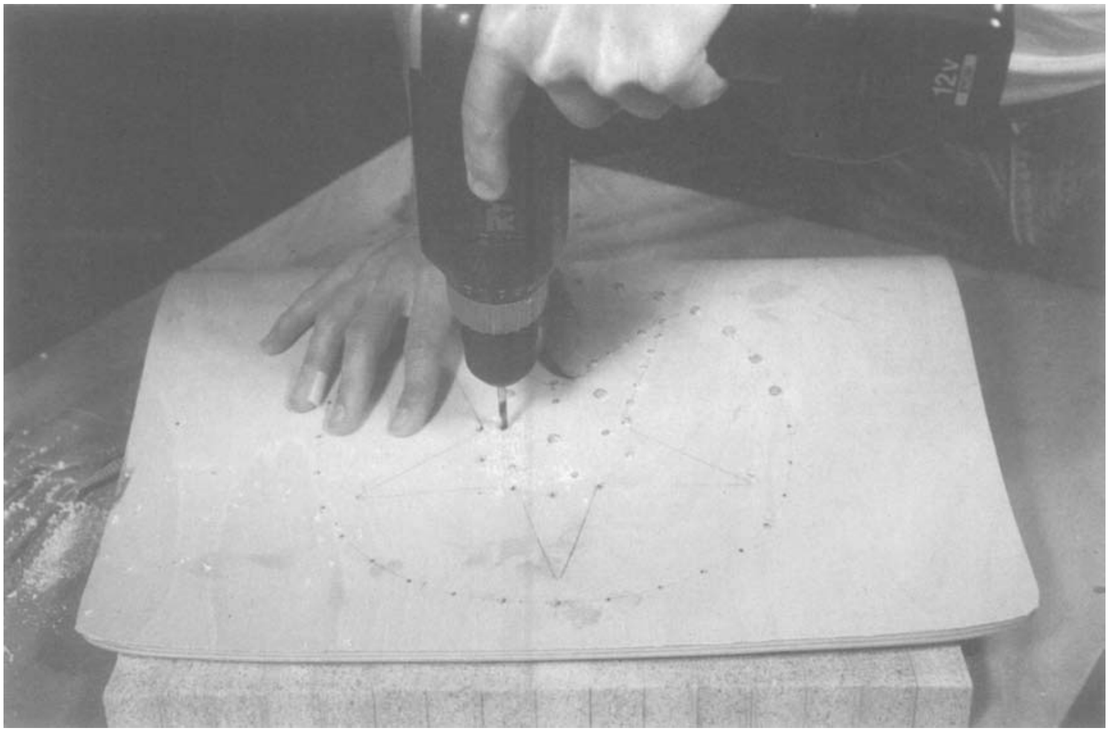

Figure 34. Drilling holes in a seat.

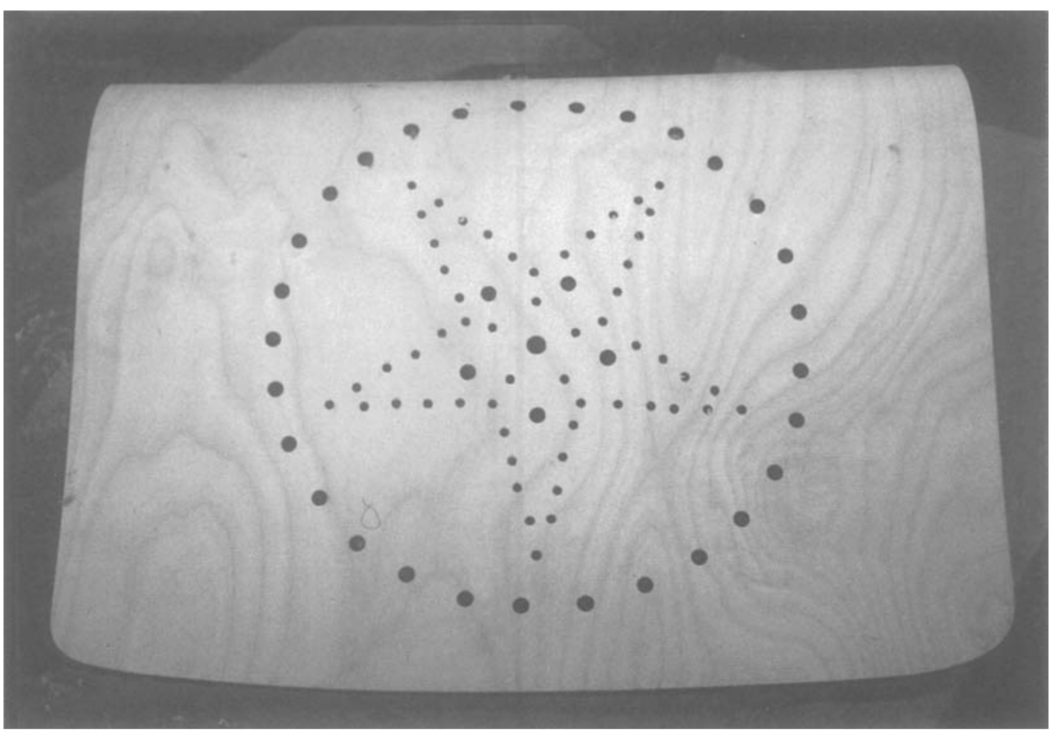

Figure 35. Seat after fabrication, but before application of finish.

Figure 36. Completed seat with chair assembly, including iron supports, wooden back and coat rack with batten.

Acknowledgements

The authors of this paper would like to thank the following people for their help and support with this project: Dawn Heller, Paul Koenig, Lisa Kurtz, Greg Landrey and Melissa McGrew.

Endnotes

1. Information on William Wagner and the history of the Institute are drawn from primary sources held by the Archives of the Wagner Free Institute of Science. See also Bolt, Eugene and Susan Glassman. 1990 Wagner Free Institute of Science Historic Landmark Nomination.

2. Wagner Free Institute of Science. Act of Incorporation, March 9, 1855; Supplementary Act of Incorporation, March 30, 1864, and Deed of Trust of William Wagner and Wife, May 30, 1864, Philadelphia: Wagner Free Institute of Science, 1920.

3.The receipt records that the seats were received from the Meade Post, a chapter of the Grand Army of the Republic veteran's group. Dr. Anthony Waskie and Eric Schmincke of the G.A.R. Museum provided assistance in tracing the Meade Post at the time the seats were purchased.

4. A short history of the Concert Hall is given in Joseph Jackson's *Encyclopedia of Philadelphia*, Harrisburg: The National Historical Association, 1931. Vol. II, pp. 512-513. Photographs of the Hall during the period that it housed the Free Library appear in Robert F. Looney, *Old Philadelphia in Early Photographs, 1839-1914*. New York: Dover Publications, 1976.

5. The first branch of the Free Library of Philadelphia opened at the Wagner Institute in 1892. This connection may have facilitated the exchange.

6. Conservation Assessment, Catherine Hawks, Conservator, November 1992. Conservation Conditions Survey and Planning Analysis, William Stivale, Building Conservator, November 1992.

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McGrew, M. March 2000. Personal communication. Conservation Fellow, Winterthur Museum, Wilmington, DE.

Morley, J. 1999. *History of furniture: twenty-five centuries of style and design in the western tradition*. Boston: Little, Brown and Co.

Materials

1. Adhesives:
   Hide Glue

   Urea-Formaldehyde Resin: National Casein of New Jersey, 401 Martha's Lane, Riverton, NJ 08077

2. Fill Materials/veneer:
   Araldite AV 1253, Carvable Paste Wood: Ciba Specialty Chemicals, Performance Polymers

   Birch veneer, 1/20" Rotary cut Birch: Veneer Products of NB (1981) Ltd., 12 Alpha St., Napadogan, NB E6B1Y6 Canada

3. Finishing Materials:
   Ciba-Geigy Orasol dyes
   Windsor & Newton Artists Oil paint
   Windsor & Newton Artists Water Colors
   Mohawk Blendal Stain Concentrated Dry Pigments
   Belen A.C. Garnet Shellac Flakes
   Belen Blue Label Paste Wax

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REPLICATION OF NEOLITHIC PLASTER STATUES: INSIGHTS INTO CONSTRUCTION AND FORM

Carol A. Grissom

Abstract

Large Neolithic lime plaster statues excavated in 1985 at 'Ain Ghazal (Jordan) were replicated to more correctly interpret evidence of construction. The process, including a failure that illuminated the minimal structural role of the armature, also enhanced understanding of the behavior of materials during statue fabrication. The most valuable contribution, however, may be that replication provided insights into artistic choice and original appearance, which are of particular importance because of the statues' rarity and early date.

1. Introduction

Neolithic plaster statues found at 'Ain Ghazal (Jordan) were replicated at the completion of a long-term conservation project (Grissom 1996, 1997, 2000a) in order to improve interpretation of construction evidence. The statues had been buried in a cache during the 8th millennium B.C., and they were block-lifted in 1985 shortly after discovery (Rollefson and Simmons 1987). The block was transported for laboratory conservation to the Conservation Analytical Laboratory (now the Smithsonian Center for Materials Research and Education), just outside Washington, D.C. Five statues were ultimately reassembled, including two standing figures and three two-headed busts (Fig. 1). The tallest statue measured over one meter in height, and the heaviest is estimated to have weighed 28 kg. when intact.

The extraordinary survival of the plaster for more than 9000 years may be attributed to its water-resistance, apparently provided by incorporation of lime in the plaster. Analysis indicated that the lime content was about 10% and that remaining plaster consisted mainly of powdered calcium carbonate; in addition, clay was present at about 10% by weight as were smaller amounts of quartz and feldspar. The plaster is chemically identical to marl found on the site, and the lime must have been made from the marl by heating it to temperatures in excess of 600°C (Boulton 1988, Grissom 1997). The plaster had suffered fragmentation during burial, but this offered one advantage: it gave access to statue interiors left hollow by complete disintegration of armatures. Impressions on interior surfaces revealed that the armatures had been made of reed bundles tied together with cordage.

This is not the first or only cache of "monumental" Neolithic plaster statues found in the ancient Near East, but these statues are among the largest and best preserved, and the two-headed busts are unique within the genre. Plaster statues were first found at Jericho by Garstang (1935) and later by Kenyon (1960), although survival in both instances was limited because modern conservation methods, notably blocklifting, were not employed. The largest cache of such statues

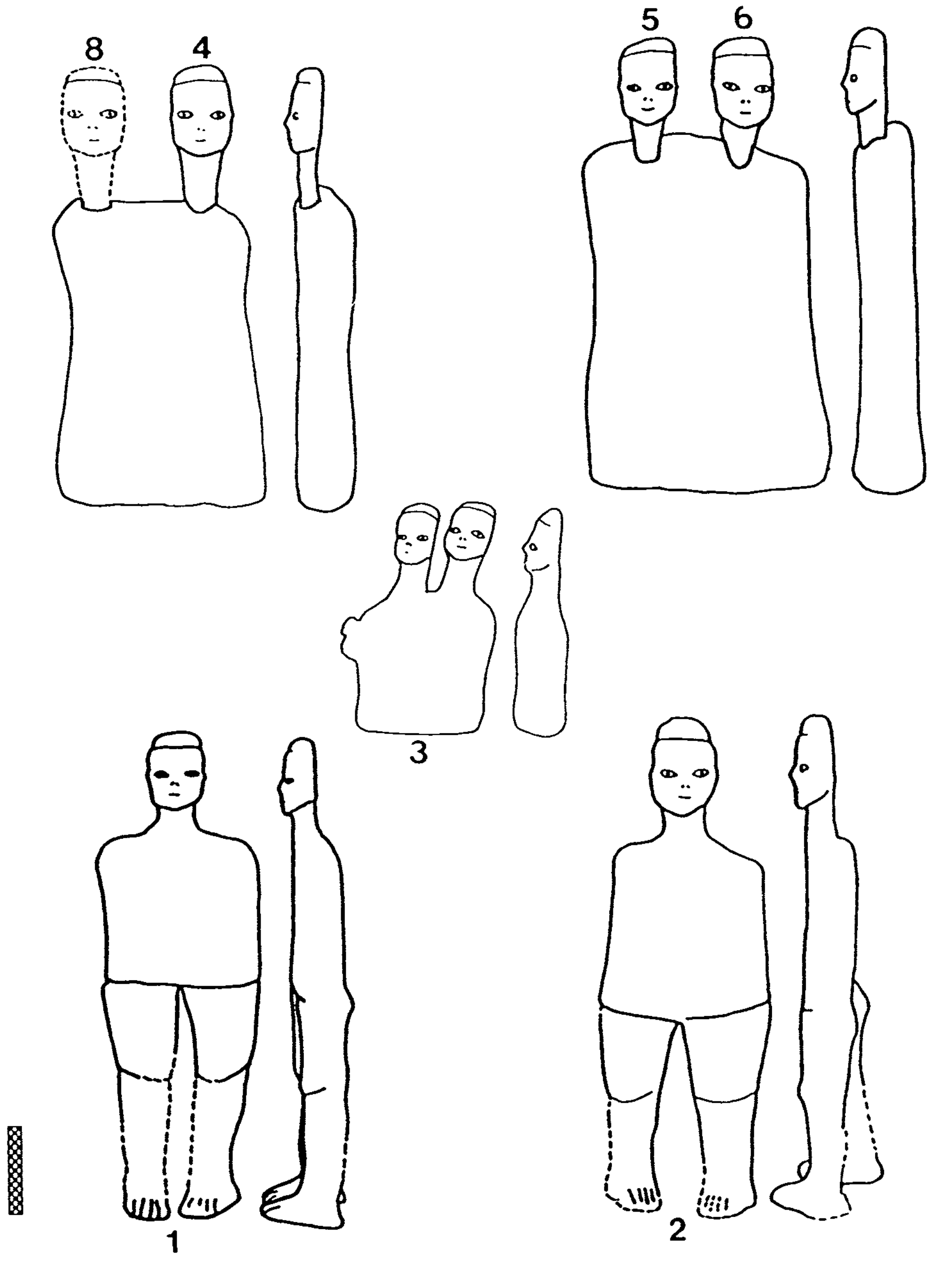

Figure 1. Drawing of 'Ain Ghazal statues excavated conserved at the Smithsonian, identified by numerical designations. Dashed lines indicate modern compensation at perimeters. Scale measures 20cm.

found to date (about 28) was discovered at 'Ain Ghazal two years before the cache conserved near Washington; conservation of this large cache of statues is being done in London (Tubb 1985). Although they are the property of the Hashemite Kingdom of Jordan, the two 'Ain Ghazal groups will subsequently be referred to as the Washington and London caches for the sake of simplicity. As would be expected for artifacts from the same site, these statues have many similarities (Tubb & Grissom 1995), especially in comparison to statues found at Jericho. They have similar plaster composition, were made on reed armatures, and have prominent eyes decorated with bitumen. There are differences, however, probably because fabrication occurred at different times. Limited C-14 analyses of associated charcoal suggest dates for the Washington statues several centuries later than for the London statues. The Washington statues are significantly larger and simpler in form: without the waists, arms, hands, body paint, or sexual features found on some London statues. In accordance with their size, armatures for the Washington statues are also larger and more complex. For example, while London busts are made on a single reed bundle, the comparable small Washington bust (statue 3) was constructed on an armature made of at least 8 bundles. While London figures were constructed on armatures made of five reed bundles, armatures for the two Washington figures were composed of 26 and 27.

Archaeologists and art historians have suggested that these large Neolithic plaster statues represented deities, ghosts, ancestors, or revered community members (Schmandt-Besserat 1998), but evidence of their usage and meaning is limited. The period is prehistoric, which by definition means that there is no written record to inform about these matters. Flat bottom surfaces and other evidence indicate that the statues were displayed upright, but all statues have been found in pits, apparently buried when no longer used; thus, burial context provides no clues about usage. Later tradition also provides no assistance because the practice of making large-scale plaster statues disappeared after the Neolithic period. The two-headed busts are particularly uninformative, as the faces and adjacent torso areas of each pair are undifferentiated. Because of this dearth of information, any evidence that sheds light upon artistic intent and original appearance is potentially valuable, especially given the statues' rarity and early date.

My original goal of more assuredly interpreting evidence of construction was not only met but exceeded through making replicas, and this paper is intended to provide an example of what can be learned by replication. Detailed descriptions of construction evidence referred to in this paper and a more complete synthesis of such evidence and replication-derived information are found in another publication (Grissom 2000b).

2. Experimental approach

Reeds (*Phragmites* sp.) were obtained from a nearby estuary to make replica armatures, and they were bound together with commercial jute twine of approximately the same dimension as the original. Plaster was formulated to simulate the original composition. Small-scale experiments were done using raw material (marl) obtained from the site, powdered and mixed with about 10%

lime made by slaking laboratory-grade calcium oxide. These tested hypotheses about plaster application, mainly related to modeling of the heads. Because raw material from the site was limited, however, full-scale replicas of a large two-headed bust and a figure were made using ground limestone and hydrated lime purchased from a local hardware store. Clay was obtained from several sources, thus accounting for variations in coloration of replica plaster, notably the "whiter" appearance of plaster used to model the heads.

3. Results

Replication proved useful in several ways that may well apply to other projects. First of all, it was unmatched in providing visceral insights into original fabrication through the experience of handling similar materials. Replication, for instance, made manifest the difficulty of manipulating heavy plaster statues during construction. The weight of the original statues had been observed during their reassembly, but replication palpably demonstrated how much heavier they were when wet. Furthermore, the difficulty of handling plaster and reed statues that are heavy, wet, and easily damaged when flexed became clear.

Secondly, replication made manifest rationales underlying fabrication choices. Evidence indicated that the original statues were largely plastered in horizontal position and placed upright only at the final stage of fabrication, but the reason for this procedure was unclear. Before replication was done, it seemed that modeling the statues in vertical position would have been easier because it would allow working in the round. Fabricating statues while horizontal seemed more difficult as it would require reversal to complete the other side and would necessitate manipulation while statues were wet. Replication, however, showed that the statues could only be made while horizontal on account of their large size, as will be detailed below in the section on general plaster application.

Thirdly, even a replica failure proved instructive. When a large amount of plaster was applied to reed bundles, it failed to adhere to the armature if the object was moved shortly thereafter; only after the plaster was left over night and had noticeably stiffened could the item be safely reversed or stood up. Plaster was usually covered to retard drying so that it would not crack, but in one case a two-headed bust replica was inadvertently left uncovered and found cracked the next day. A plaster repair was made, but when the next step was attempted -- placement of the replica upright -- the newly applied plaster fell off near the repair since it had not yet stiffened. Where this occurred, the reeds bent like cooked spaghetti and revealed that they were saturated by moisture, apparently absorbed from the plaster. Attempts to keep the bust upright were unsuccessful, and it slumped dramatically to one side (Fig. 2), then fell over. This demonstrated not only how little strength the plaster had before it set but also how wet and unsupportive the reeds were until the statue had dried out. It was concluded that, in addition to diminishing statue weight and plaster

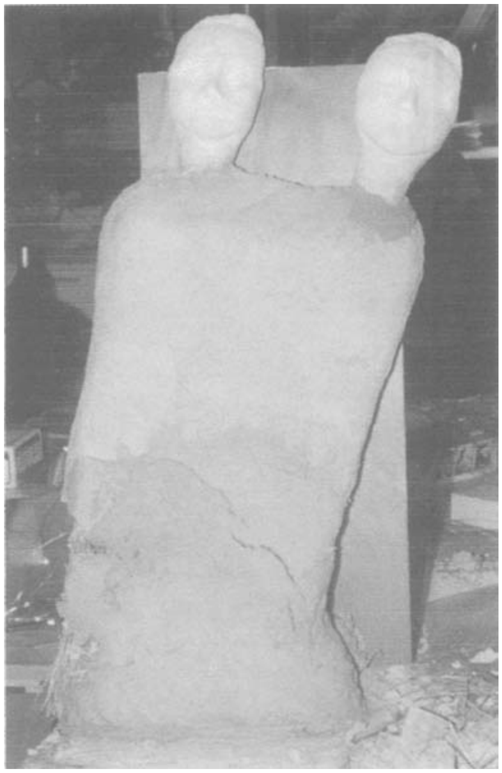

Figure 2. Replica of a large 'Ain Ghazal bust, shortly after it was placed upright and just before it fell over.

shrinkage, the armature did not serve as the primary support for the statues but only as a passive support on which plaster rested until it had set.

Specific information gained from replication follows.

3.1 General plaster application

Practical experimentation showed that plaster had to be applied to the upper surface of reed bundles placed flat on a horizontal surface in order to make statues of a size comparable to the ancient statues. When attempts were made to apply the same quantities of plaster as used for the ancient statues to armatures standing upright, regardless of consistency the plaster either fell off or slumped uncontrollably downwards. The pyramidal shape of a bust excavated by Kenyon at Jericho illustrates the sagging of plaster as a result of upright modeling, which the smaller size of the bust probably allowed (Kenyon 1960: Plate 12).

Horizontal surfaces were found to flatten during replication, resulting in the flat front and back surfaces characteristic of the ancient statues, most pronounced for thighs, torsos, and backs of heads (Fig. 3). Such surfaces facilitated manipulation during replication because they matched flat auxiliary supports used to aid in reversal and upright placement.

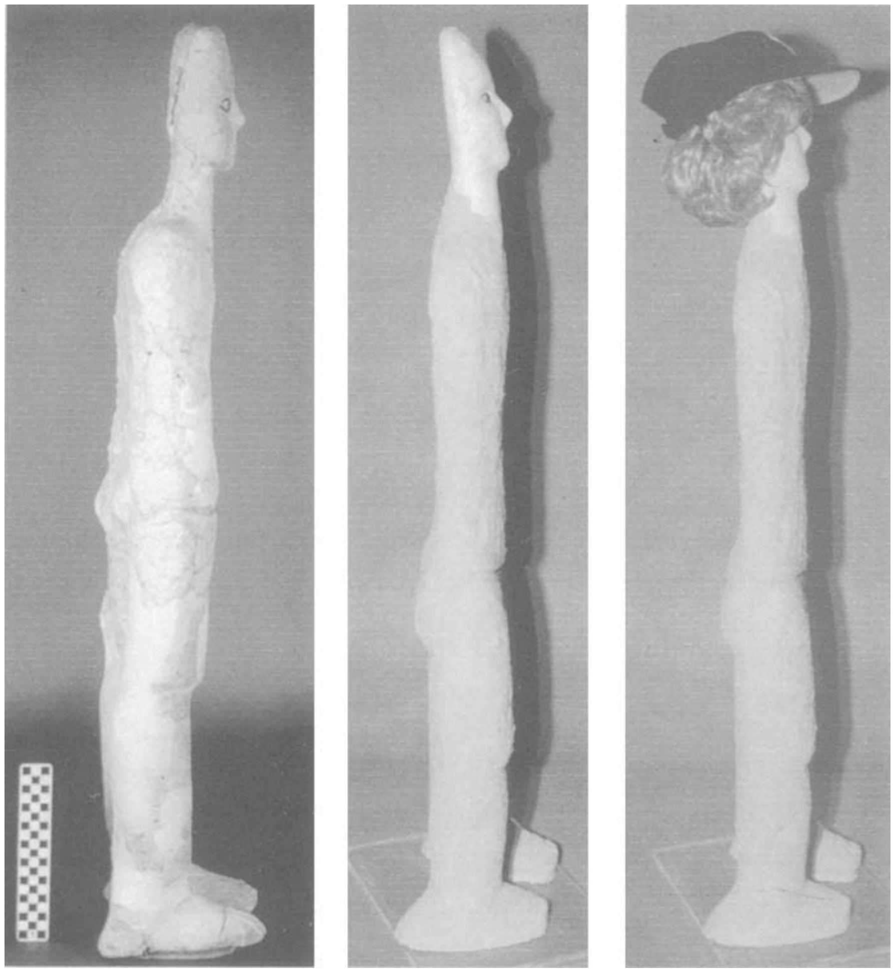

Figure 3. Profile views of a figure: (a) 'Ain Ghazal statue 1, (b) its replica, and (c) the replica with wig and baseball hat.

3.2 Heads

Replication of statue heads not only confirmed ideas about construction based on impressions in the plaster but also provided evidence of original appearance. Impressions on interior surfaces indicated that each original statue head had been plastered on one end of a long reed bundle, which was then incorporated in the torso armature. Before replication, I had presumed that each head had been modeled by applying plaster to the bundle on what would become the back of the head and that then the bundle was turned over and laid on a horizontal surface to model the features of the face. Replication confirmed that this was the only way in which the statue heads could have been modeled. Attempts to model a head on a long reed bundle in vertical position, for instance, showed that proposition to be preposterous. Replication also showed that, in contrast to the case for the larger partially plastered legs or torsos, the relatively small size of the heads allowed them to be turned over immediately after the back was plastered. As a result, the damp plaster on the back took the impression of the surface upon which it lay, reflecting in detail the flat table surface in the case of the replica (Fig. 4a). Thus, the replica demonstrated how readily wet plaster of an original head might have become impressed by a mat or a similar man-made material upon which it lay, as apparently occurred for the heads of statues 1 (Fig. 4b) and 2. Later on during the finishing phase, the ease of smoothing away impressions from damp plaster showed that any "mat" impressions could have been removed without difficulty, had the original fabricators chosen to do so. It seems likely that statue makers intentionally did not remove the marks because they knew in advance that the areas normally covered by hair would be covered with wigs or headgear. Additional evidence of anticipated use of wigs or headgear is provided by modeling of recessed brows upon which such items would conveniently fit.

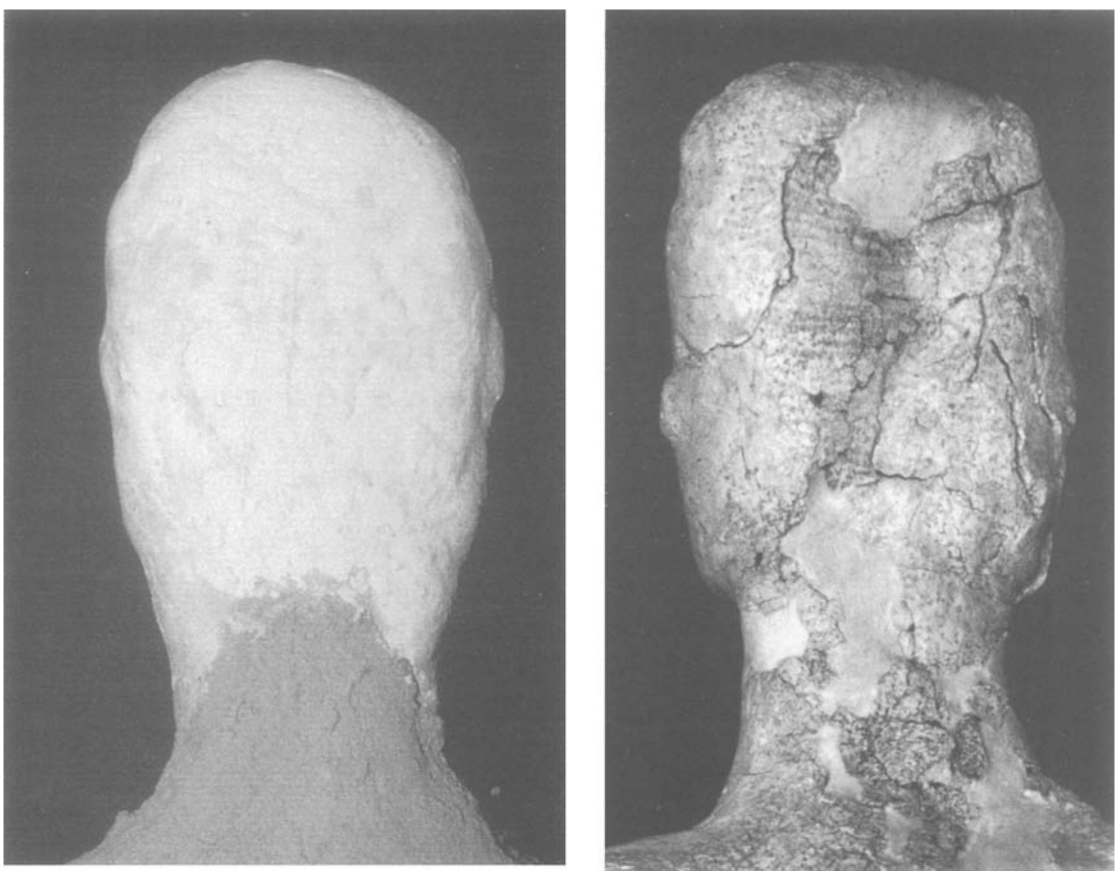

Figure 4. Backs of statue heads: (a) replica and (b) 'Ain Ghazal statue 1, showing "mat" impressions.

3.3 Two-headed busts

Replication of the large two-headed busts illustrated how the process provided information about a particular limitation on statue shape. In addition to flat front and back surfaces, the ancient busts are shallow and regular in depth. I had questioned why the statues had not been made more three dimensional, and the probable answer arose during replication. As the busts lay flat on a table during plaster application, plaster slumped at the statues sides. Unacceptable slumping would occur with increased depth, thereby preventing greater three-dimensionality.

3.4 Figures

For the two-legged standing figures, a major purpose in making a replica was to assure myself that such statues could be fabricated in pieces (head-and-torso and separate legs) while horizontal and then joined in upright position. Plaster impressions indicated that this was the case, but some doubt remained because of damage in the hip regions of the ancient figures. This question was of further interest because there was clear evidence that the smaller London figures had been made differently: plastered on armatures which were single units. Moreover, I had assumed that making the figures in pieces would defeat the purpose of an armature, which I had thought was to provide structural unity for the large figures with their appended legs. I thought, too, that it would be difficult to place each leg upright, as their large thighs make the legs top heavy; and then to assemble the head-and-torso upon them, given that the individual pieces have to be reasonably damp so that they adhere properly.

Full-scale replication of the two-legged statue showed that pieces fabricated separately were more easily assembled than anticipated. The head and torso were plastered sequentially (Fig. 5a, b, c), while at the same time each leg was modeled separately by applying multiple layers of plaster to leg-length bundles (Fig. 5d, e). After the legs were placed upright, the torso-and-head section was joined to them with plaster (Fig. 5f, h, i). Interestingly, depressions in the torso-and-head section of one ancient figure (statue 1) reflect natural hand positions during placement of the torso on the legs, as captured by photographs made during similar reassembly of the ancient statue 2 (Fig. 5g). As a result of replication, it became clear that such a large plaster statue had to be made in pieces because, although still somewhat difficult to accomplish, it would be easier to reverse the individual pieces. Probably to build up sufficient thickness to support the large torso, layering of the plaster showed that the legs were reversed three times. Reversing a large, heavy figure without damaging it seemed inconceivable. Fabrication of the statues in London on single armatures was presumably possible because of their smaller size, although much of their fabrication methodology remains as yet unclear.

4. Implications for original presentation and artistic intent

Because of replication, it became clear that the original statue makers must have been limited by their materials in choosing to create large-scale statues. Forms were simplified, and human features such as waists and arms were omitted. It seems almost certain that the statues were displayed with wigs, clothing, or other materials to compensate. Thus, the statue makers did not waste time in smoothing away "mat" impressions on the backs of heads or polishing rough surfaces on bust torsos because those surfaces would be covered. Direct evidence of accessories has not been found, but it is not implausible that such items were removed before the statues were buried or that they disintegrated during burial.

The original appearance of the statues when "dressed" was likely quite different from the present appearance of the statues and was probably much more realistic. Such accessories would eliminate the space alien or ghostly appearance often accorded the statues by modern observers (Schwartz 1996) (cf. Figs. 6a and 6b). A wig could compensate for a flat head and make a statue appear more three-dimensional when viewed from the side (cf. Fig. 6c with 3c & 6d) . Display of the statues in the round also becomes plausible, whereas the flatness of the statues would otherwise only indicate display against a wall or in a niche.

Accessories or clothing might have rendered the twins distinguishable. A beard might have distinguished a man and long hair a woman, for example, as it did for an elderly heterosexual couple depicted on a third millennium B.C. two-headed statuette found at Nippur (Hamblin 1973: 103). The most likely alternative representation is illustrated by relatively common Neolithic pairs of women, identified by breasts; e.g., a two-headed stone statuette found at Çatal Hüyük (Mellaart 1967: Figs. 70-71) and a two-headed ceramic vessel found at Hacilar (Aitken *et al.* 1971: Plates 4,5).

While the plain unsmoothed bust torsos indicate that they were probably covered in entirety, modeling of the buttocks and knees suggests that the bodies of the figures were partially clothed. The figures' lack of arms could have been disguised by a shawl or similar item, as it is by the beach towel around the shoulders of the replica (Fig. 7a). Wearing a bikini is not so far fetched when compared to the costume of a figurine from Neolithic Hacilar (Fig. 7b in Mellaart 1970: Fig. 195).

5. Conclusion

In summary, replication can be a useful adjunct to evidence provided by in-depth examination of artifacts. It is particularly worthwhile in providing other valuable insights when unusual materials or puzzling construction are found, as was the case for statues found at 'Ain Ghazal.

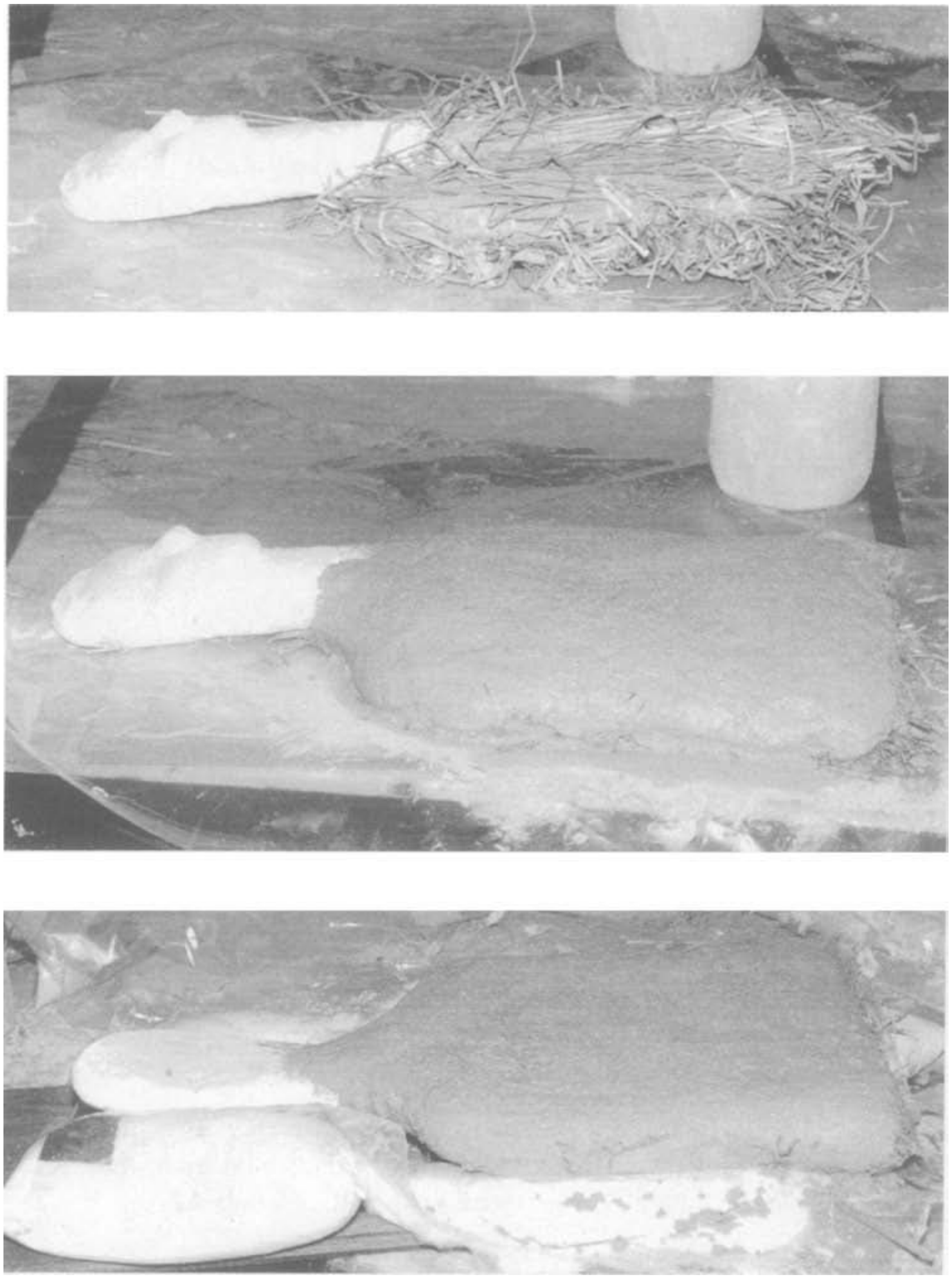

Figure 5. Fabrication of replica head-and-torso section, including (top) torso armature constructed around the plastered head, (center) front of torso plastered, and (bottom) back of torso plastered.

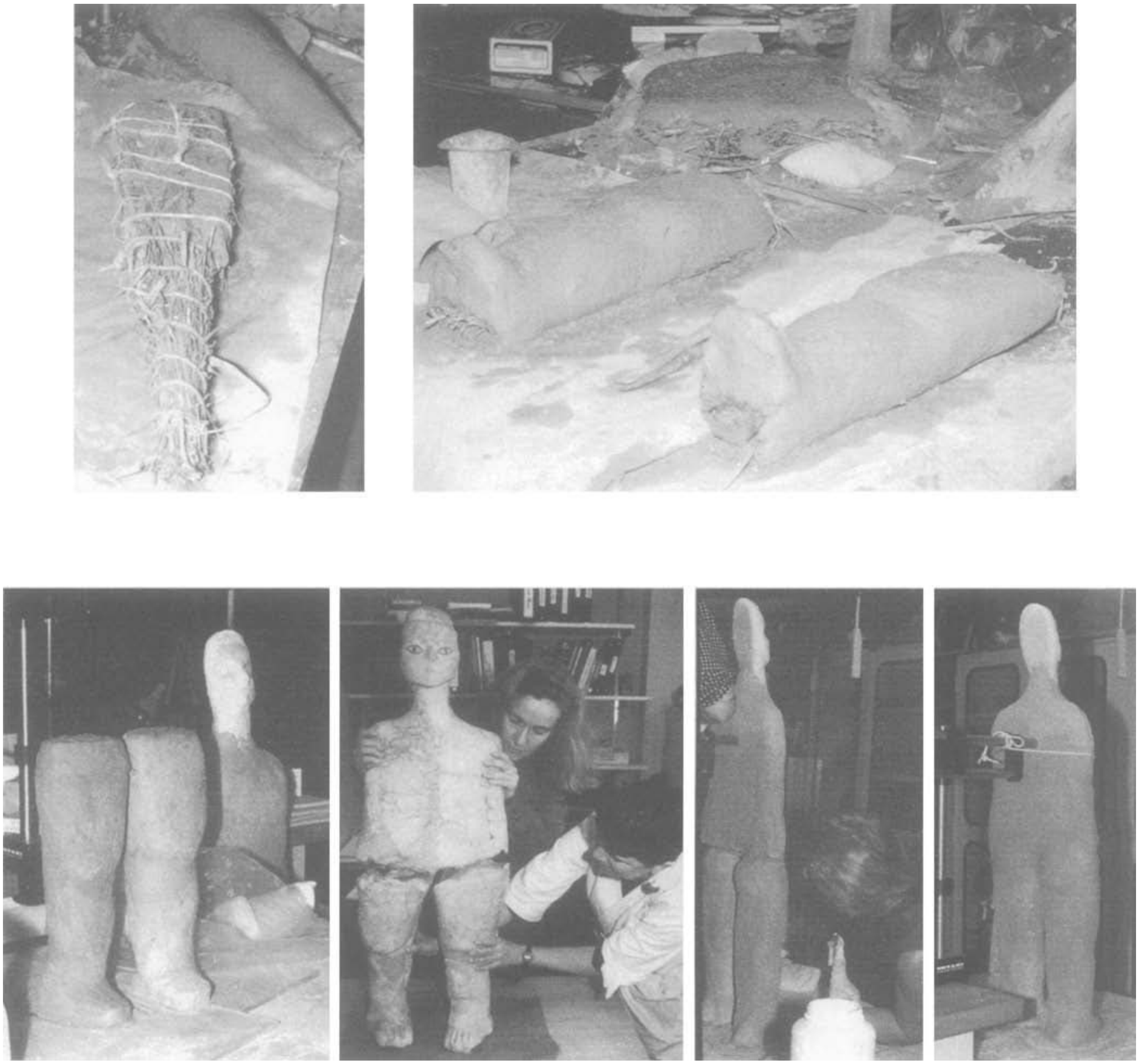

Figure 5. Top row: Fabrication of replica legs, including (left) reed bundles partially plastered and tied together with a spiral of twine and (right) after horizontal plastering was complete but before placement upright. Bottom row, left to right: (1) Joining of figure pieces, including replica legs placed upright, (2) 'Ain Ghazal statue 2 torso being placed on legs in the same manner as for the replica statue, (3) joint between legs and torso of replica being plastered, and (4) replica secured after plastering was complete.

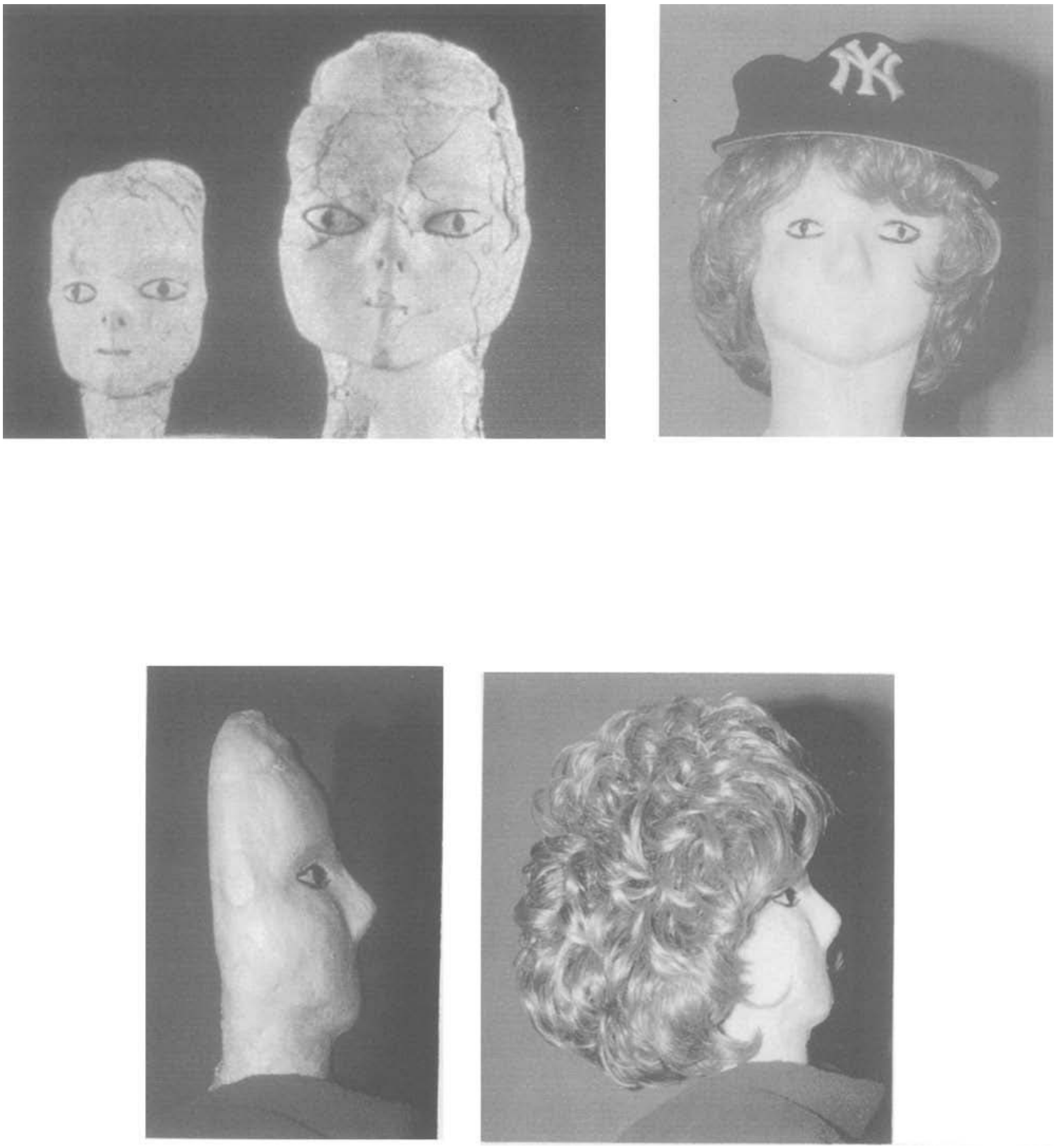

Figure 6. Front view of (a) 'Ain Ghazal heads for statues 5 and 2 and (b) replica head with wig and baseball hat; profile view of (c) replica head and (d) replica head with wig.

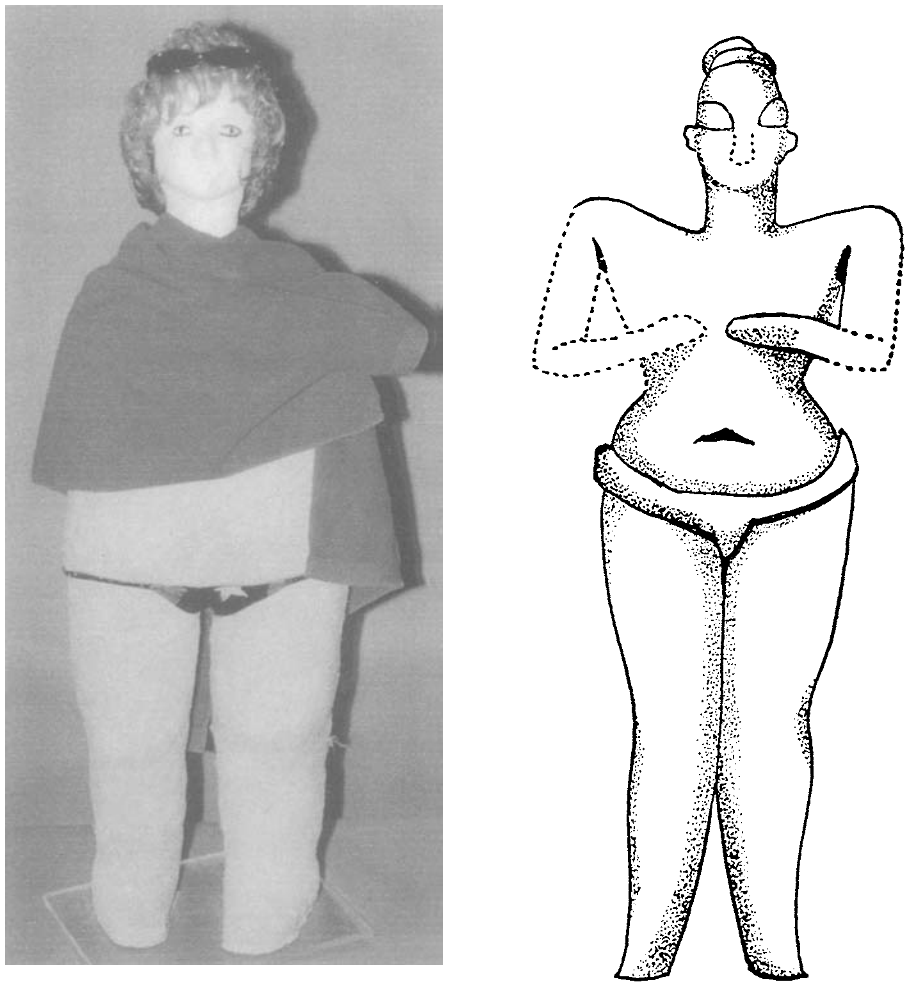

Figure 7. (a) Replica figure wearing bikini, beach towel, wig, and sun glasses; and (b) figurine from Hacilar (courtesy University Press, Edinburgh).

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UNMASKING AN ARTIFACT TECHNOLOGY: TEXTILE-CLAY COMPOSITES FROM ANCIENT MESOAMERICA

Harriet F. Beaubien

I. Introduction

Two sites in the Petexbatún region of the Petén in lowland Guatemala have recently yielded fragments of an artifact material type that has not been previously documented in the Maya archaeological literature. In 1993, several "sherds" were excavated at Las Pacayas from unstratified ceremonial deposits in a cave underlying the site's center, called Cueva de los Quetzales (Fig. 1; Brady and Rodas 1995). The deposits range in date from the Late Preclassic to the Late Classic Maya period (before AD 250 to AD 900). Although not conjoining and too few to determine artifact form, the three Las Pacayas fragments were the first to provide analytical results that suggested the use of a composite material, in research carried out at the Smithsonian Institution's Conservation Analytical Laboratory (now the Smithsonian Center for Materials Research and Education [SCMRE]; Kaplan 1994).

In 1998, excavations at Aguateca yielded significant fragment clusters of a similar material (Inomata et al. 1998). These were part of fragmented, burned but otherwise undisturbed floor assemblages from a probable royal palace located in the site's elite center. The destruction event which ended Aguateca's occupation has been dated to the Late Classic period (around AD 800). The Aguateca fragments, analysis of which has expanded our understanding of this material (Shah 2000a), have additionally provided information about artifact forms (Fig. 2). Conservation involvement from the time of excavation and during all subsequent processing has contributed to their identification [1]; two of the skillfully crafted objects appear to be a mask and possible headdress elements.

Although there are differences in appearance, both the Las Pacayas and Aguateca fragments are composed of multiple layers of woven textile embedded in a clay matrix, based on careful examination and materials analysis [Kaplan 1994; Shah 2000a; Beaubien and Kaplan (in press)] (Figs. 3, 4). In the absence of later ethnohistorical information and other excavated examples, little else is known about this unusual material beyond what can be inferred from the analyses. Because of these limits, replication studies carried out in the laboratory have proven to be particularly useful in developing and testing hypotheses about how the composites were assembled and shaped into objects. The results of these studies are the focus of this paper.

II. Background Information on Composites

The term "composite" best describes the material from which the Petexbatún objects were made, and modern industrial practice provides a useful framework for examining aspects of fabrication. A composite is defined as the material that results from the synthetic assembly of two or more materials (Rosato 1982). These are typically a filler, which functions as the principal reinforcing or load bearing element, and a matrix or binder, in which the filler is embedded and which provides overall support and protection. The composite's characteristic format is a layered arrangement of filler in matrix, termed a lamina as a single layer or a laminate when several of these are stacked, often with changing orientations and usually bound together with the same matrix material as is used in the individual laminae (Jones 1975).

Composites are typically assembled and the end-product fabricated in the same process. This process is called lay-up, which can be done by hand, using sprays, by injection, etc. All of these methods require a mold, which enables a specific shape to be formed and supported during curing of the composite. The molds can be open forms (either convex or concave) or closed. In modern practice the side in contact with the mold is meant to be a finished surface; a parting agent is necessary and pigments or other surface finishes are usually incorporated in it (Wittman and Shook 1982; Hancox 1983). An enormous variety has been tailored industrially, and many are characterized by high structural efficiency, exceptional strength and light weight (Rosato 1982; Jones 1975). Examples include laminated fiber-reinforced plastics for helicopter blades and many aerospace applications, cast materials for setting broken limbs, fabrics for air mattresses, tennis rackets, etc.

There are several noteworthy antecedents to these modern composites. Light-weight sturdy objects, such as globes, were mass-produced in the 19th century using *papier-mâché*. Paper pulp or paper sheet, saturated in various glues and drying oils, was built up in thin layers on a mold and then decoratively finished once dried (van der Reyden 1986). In late-period Egypt, inner mummy cases were often made of *cartonnage*, a composite of linen (sometimes papyrus) soaked in gum. Layers were built up on a core ("former") of mud or straw and then finished with a layer of fine gesso plaster as a base for applied decoration or painting (Adams 1966). The previously unknown composite type used by the artisans in creating the objects excavated at Las Pacayas and Aguateca shares many aspects of production with these.

III. Fabrication of the Petexbatún Artifacts

A. Component selection

A. 1. Textile filler

Woven cloth functions as the filler in the Petexbatún composites. It is known almost entirely through imprints of individual threads and woven structures in the clay matrix, where outermost surfaces are abraded or, in cross-section at break edges, as a regular array of voids once occupied by the yarns (Figs. 3, 4). In a few instances, the Las Pacayas fragments preserve what look to be actual fibers (Fig. 5). Several of these generated Fourier Transform infrared spectra comparable to cellulosic materials (Fig. 6), although most registered a high silica content by energy-dispersive spectroscopy (EDS) analysis suggesting that the fiber structure had been replaced through a silicification process. In scanning electron microscope (SEM) images, individual fibers were too degraded to identify, but their size (~10μm diameter) suggested cotton or bast (Kaplan 1994).

Both Las Pacayas and Aguateca textiles utilized Z-spun threads (Fig. 5). The predominant yarn diameter is about 0.5-0.75mm, although both thicker and finer yarns also occur. Aguateca textiles are primarily variations of plain weaves, but one possible twill weave may be present. These were studied easily using polyvinyl siloxane casts taken from impressions in the clay matrix of approximately twenty fragments (Shah 2000a)[2]. The plain weaves are primarily balanced types of several densities. Most common are an open variety at ~6 x 8 threads per cm (Fig. 7a) and an intermediate variety at ~11 x 12 threads per cm (Fig. 7b); one example of a fine variety, at ~17 x 20 threads per cm, was noted. Warp- or weft-faced plain weaves (at ~6 x 15 threads per cm) are also common (Fig. 7c). All Las Pacayas textiles, studied from impressions in the clay matrix, are plain woven with paired yarns in one of the directions (at ~8 single x 12 paired threads per cm) (Fig. 7d) (Kaplan 1994).

To explore aspects of cloth selection, replicas were made in the laboratory using modern textiles of various fiber types and weave densities, including a fine cotton cheesecloth, various densities of plain woven fabric in cotton, linen and agave, and a coarse burlap (Fig. 8a). Pieces measuring several centimeters in each dimension were dipped in a clay slip and stacked in three or four layers on a wooden surface [3]. Samples in one group were manipulated into folds to see how the fabrics responded. All cotton fabrics proved malleable and responsive to shaping, while linen and particularly agave and burlap fabrics remained stiff.

Using a woven textile as filler offered the artisan several advantages, notably a thin unified structure and an ability to drape. While various plant fibers, such as cotton and agave, were available to the Maya for cloth production, the results from replication argue for cotton as the cloth fiber used, at least in the case of the Aguateca mask.

A. 2. Clay matrix

Elemental analyses by EDS on small samples from the Las Pacayas fragments produced a profile that would be expected of clays, with prominent silicon and aluminum, and smaller amounts of calcium, magnesium, potassium and iron (Fig. 9); these were similar to EDS results obtained on an Aguateca sample (Kaplan 1994; Shah 2000a). SEM images of several Las Pacayas samples showed a glassy material with fused particles, typical of a fired ceramic (Fig. 10), although x-ray diffraction analysis also suggested the presence of some unfired clay (Kaplan 1994).

The colors exhibited by fragments from both sites were typical of ceramic, ranging from orange to black. The notable exceptions were internal layers of Las Pacayas fragments, visible in freshly cut cross-sectional surfaces; these appeared white, becoming black where adjacent to textile voids (Fig. 11). After a sample was heated, however, these color differences disappeared: at 700°C the layers began changing color, becoming a uniform orange terra-cotta color at 850°C in an oxidizing environment (Kaplan 1994). This supports the identification of the matrix as a clay. The matrix in samples from both sites appears homogeneous and fine-textured, suggesting use of a well-levigated slip. Replicas produced with an unmodified slip made from fine clay exhibited a smooth-textured surface that reflected the topography of the underlying textile weave, and produced clear textile imprints, similar to features of original samples (Fig. 8a).

B. Composite assembly

Although the Las Pacayas fragments are notably thicker than those from Aguateca (up to 1 cm vs. 1-2 millimeters, respectively), the composite assembly appears to be the same. In cross-section, the clay layers are relatively regular in thickness and closely follow the contours of the cloth (Figs. 4, 11). The laminate is well-melded, with no separations apparent within the clay layers or evidence of delamination at the textile surfaces. These features suggest that the textile pieces were coated in slip first before layering, creating even clay layers that fused during assembly. Comparable results were obtained by replicas made in this manner. Those made by first layering dry or water-wetted cloth pieces, and then applying slip, produced irregular clay layers. Folded shapes collapsed, unless textile pieces were pre-coated in slip to provide necessary support.

Laminate cohesiveness appears to have been affected by other aspects of the cloth. Those replicas that exhibited delamination problems during subsequent handling were made with burlap, where the fabric was too thick relative to the slip layer, or with fabrics whose weave was much tighter than that of documented imprints (Fig. 8b). Sound laminates were produced by a good quality cheesecloth whose weave density fell within the ranges measured on original pieces, although the individual threads were thinner.

Applying replication results to the Petexbatún composites, cotton was the most likely fiber used, and as a textile, provided an effective way to create thin sculptural forms, offering ample surface area to distribute the shrinkage stresses that the clay slip would develop during drying. The relative openness of the handwoven structure permitted the clay slip to penetrate from one side to the other, and wet-on-wet application of individual layers resulted in an effective laminate.

C. Artifact shaping

The Petexbatún composites would have required a form (or mold) to support the textile-clay layers as they were built up and until they had dried. Several aspects of the Aguateca mask proved useful in hypothesizing how the layering process progressed and the type of mold used. In general, fragment interiors tended to show more loss of the surface clay layer than the exteriors. In replicas formed with both concave and convex molds, this feature was noted on the side in contact with the mold surface; the exposed surface, where slip tended to pool, retained an undisturbed clay layer. This suggests that the interior was the side in contact with the mold, based on surface disruption; if so, then fine striations preserved in surviving surface slip may be impressions from the mold itself (Fig. 12). Because these features were noted on concave surfaces, this argues for use of a convex mold, possibly made of wood.

Replication supported this hypothesis with respect to another notable aspect of the Aguateca mask. The exterior topography is more complex than that of the interior, with elaborate folding patterns particularly around the eyes (Figs. 13a, 13b). A concave molding process would have required initial production of the artifact shape as a negative. To investigate this approach, similar shapes were modeled in plasticene, then cast in plaster; slip-dipped textile layers were tamped into the plaster mold and allowed to dry (Fig. 14). The resulting shapes on the exterior surface had neither the dimensional folded quality nor the weave distortion apparent on the Aguateca mask (refer to Figs. 2, 13b). These features were produced more easily in replicas built on convex forms, where folds could be freely formed in the exposed outer surface (Fig. 15).

While concave molds are known to have been used in the production of ceramic figurines, these objects do not have the sculptural quality seen in the mask. The indications of a convex mold are more convincing. It would have been relatively easy to carve a simple convex shape in wood, and layer the composite from inside to outside. Folded shapes and grooves could then have been freely worked into the still wet outermost layers.

D. Finishing

Some of the details seen in the Aguateca mask were not successfully reproduced as part of initial shaping. Eye openings, created by folding separate textile pieces to form upper and lower rims, bulged awkwardly and the surrounding mask surface was marred by the patchwork effect of the textile pieces beneath the clay layer. Tucking or aligning textile edges still produced messy outer borders that contrasted with the smooth lines of the original.

Instead, it became clear during replication that these details could be made as a finishing step once the composite had dried. Removed from the mold in a leather-hard state, the replicas could be handled quite easily. The thinness of the laminate, the pliable textile and the weak dry slip allowed edges to be scissor-cut (Figs. 16a, 16b). Cracks and sharp edges that occurred during this process were easily reintegrated and rounded with a brush wetted with either water or more slip. Eye holes were cut out of plain areas, and the edges rewetted and folded inward to form rims. Circular perforations, seen near the edges of the mask were made with an awl and then neatened by rewetting. At this stage, lean surfaces were easily repaired with the addition of more slip, as long as not too much was wetted up at once. This suggests an alternate explanation for the fine striations on the Aguateca fragment reverses; these may be brush marks from the reapplication of slip to the surface potentially abraded by contact with the mold. The comparability of results achieved in these replicas with details seen in the mask strongly suggests that the artisan, using appropriate tools, created the eye openings and trimmed the mask's edges once it had dried.

The final finishing step was the application of color. The exterior surface of the mask has a red pigmented slip, visible in cross-section as a thin layer (Fig. 17). EDS results indicate an iron-bearing compound, such as hematite [Shah 2000a]. Some of the decorative grooves appear to have been scored into the surface after this last colored slip was applied.

E. Hardening with heat

Tests carried out on Las Pacayas samples indicated that the clay matrix most resembled a fired ceramic, from physical properties such as hardness, ability to withstand immersion in water, and inertness to solvent and acid wetting (Kaplan 1994), as well microstructural information from SEM (Fig. 10); the material's lighter weight, compared with conventional ceramics, is due to porosity from the burnt-out textile layers. The Aguateca matrix was even more clearly a fired ceramic. Unfortunately, depositional events at both sites prevent our ability to say with certainty that heat-hardening occurred as a stage of fabrication. The Las Pacayas material may have been burned as part of ritual activity, and the Aguateca material was subjected to a devastating fire from an attack on the site's core. Until additional composite samples are located for which use-related or post-depositional heating can be eliminated, then the specifics of heat-hardening as a stage of manufacture remain conjectural.

In order to evaluate how heating might have affected the components and laminate structure, replicas were heated in an oven from temperatures of 350° to over 1150°C, at 100°C increments (Fig. 18). Fibers were charred by 350°C but detectable in some samples heated to 450°C. Samples up to this point disaggregated when wetted with water. Above this temperature, fibers disappeared coinciding with the point at which greatest weight loss occurred. Samples still showed some water-sensitivity at temperatures of 600°C; but above that, the clay became sufficiently sintered to remain intact.

In contrast to the earlier stages of its manufacture, the fired product (both original and replica) cannot be considered a composite, since the textile component was no longer present to contribute structural reinforcement. Ultimately the material's properties were a function of the surviving clay network. As the replicas demonstrated, once heat exposure began degrading the fibers, weaknesses in the laminate structure (such as those noted in Section III.B) were exacerbated. For example, delamination occurred along the planes of now-disintegrated textile layers wherever there were insufficient interlayer clay links, a problem resulting from tightly woven fabrics (Fig. 8b). This was rarely noted in the archaeological examples, where the looser handweaves permitted formation of a good clay network.

In order for such a composite material to be practical for use, I do think that the artifacts were deliberately heat-hardened as a final stage of manufacture. My working hypothesis is that the composite was processed as ceramics from the Petén region would have been, that is, fired in pits to temperatures up to approximately 650°C (Rice 1985; Bishop 2000); uneven firing environments would not be unusual and might account for color differences and rare fiber evidence.

IV. Conclusion

The skillful manipulation of textile and clay that the Petexbatún artifacts display is a good indication that they were the product of a well-developed technique. The composite's presence in ceremonial contexts and, as demonstrated by the Aguateca finds, specific use in making ceremonial gear are noteworthy. From a material standpoint, it would have been a highly suitable choice for making such items: easily shaped, rigid and water-resistant, yet lightweight enough to be worn for periods of time. The modern craft practice of *cartonería* or *papel maché* in Mexico and Central America presents an intriguing analogue to this ancient technology, sharing similarities in fabrication and in association even today with the production of ceremonial gear (Masuoka 1994).

Unfortunately, ethnohistorical sources, such as Diego de Landa's *Relación de las Cosas de Yucatán* (Tozzer 1941), do not include references to use of a textile-clay composite. Thus far, our knowledge about it is based upon an extremely small data set. To supplement information gathered from examination and analysis, replication studies have proven to be invaluable in developing hypotheses about technological choices and about the specific production steps for these objects.

Testing these hypotheses, however, will ultimately depend on finding other excavated examples. While one might assume that the fired product would be relatively robust and thus recoverable archaeologically, even conventional ceramics have been found to be susceptible to crumbling after long-term exposure to groundwater during burial or from post-excavation washing. The fact that this textile-clay composite has only been reported in these two instances may underscore its inherent preservation issues, above and beyond rarity that may be ascribed to context and to a craft practice organized to produce unique objects rather than multiples. The delicate ceramic structure and high porosity created by degraded or fired-out textiles could easily promote a degree of disintegration beyond what similarly low-fired ceramics might experience in normal archaeological contexts. Nonetheless, it is a hope that greater awareness of the existence of this composite material will result in recognition and recovery of more examples. These may help us to unmask aspects of fabrication that remain something of a mystery.

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Endnotes

1. On site, temporary facings were applied to the fragile groups to preserve their orientation and aid in the lifting process. In the project's lab in Guatemala City, small samples were tested to determine the best methods for cleaning and consolidation. Fragments were treated with a dilute acid solution to remove accretions, followed by rinsing; Acryloid B-72 in acetone was used for consolidation and reconstruction of fragments (Beaubien et al. 1998; Beaubien and Boyer 1999; Shah 2000b).

2. Impressions were made with Coltène-Whaledent No. 4805, a polyvinyl siloxane impression compound applied through a self-mixing dispenser. Original surfaces were first protected with a dilute solution of Acryloid B-72.

3. Red Clay 103 (a cone 06 terra-cotta clay, supplied by Clayworks Supplies, Inc., Baltimore, MD) was used for the replicas.

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Figure 1. Fragments from Cueva de los Quetzales, Las Pacayas
[CQ 1-18-8, CQ 1-13-10, CQ 1-13-6].

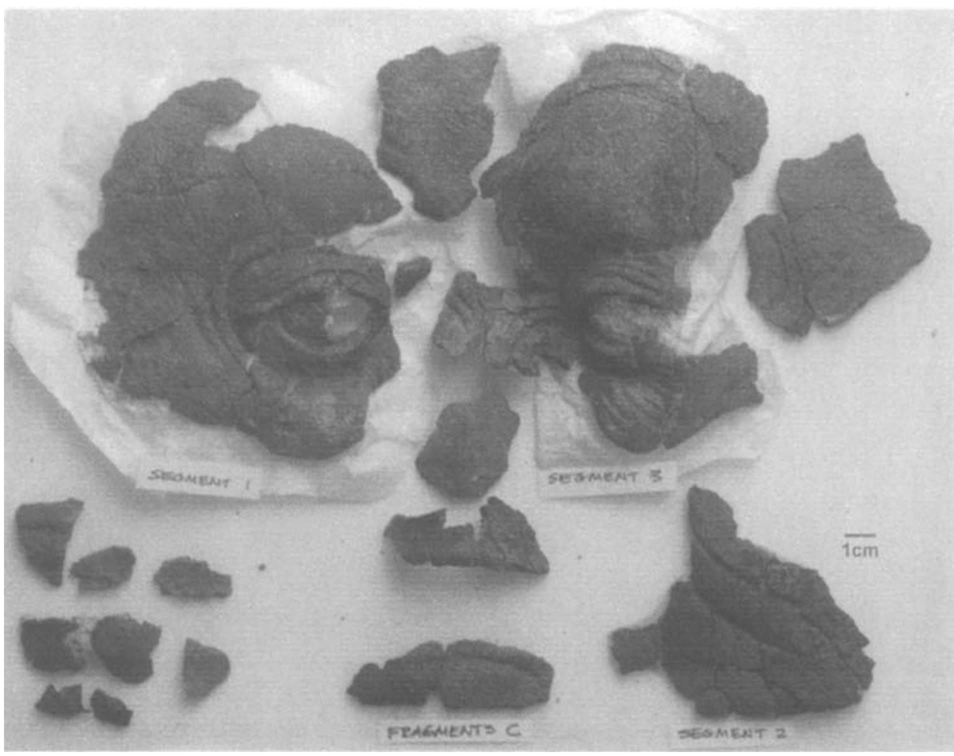


Figure 2. Mask Fragments from Aguateca [AG 22A #862].

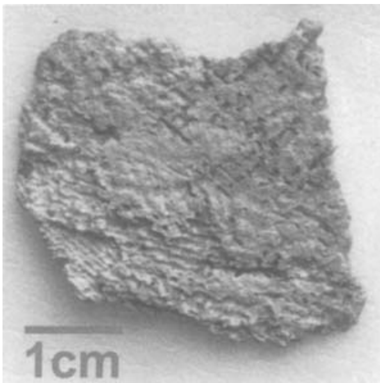


Figure 3. Interior surface showing impressions of a least three textile layers in different orientations [AG 22A #861].

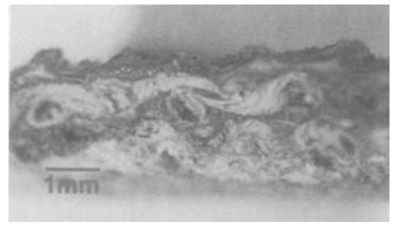


Figure 4. Laminate structure in cross-section [CQ 1-11-8].

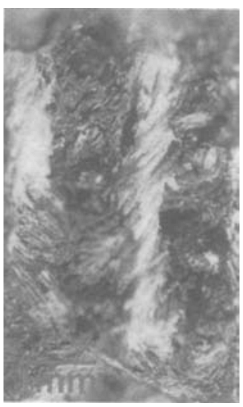


Figure 5. Z-spun thread [CQ 1-11-8].

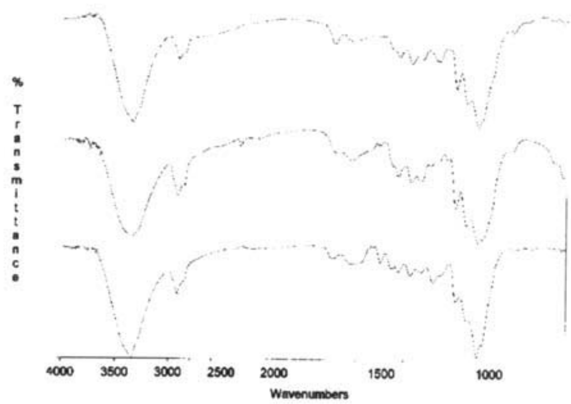
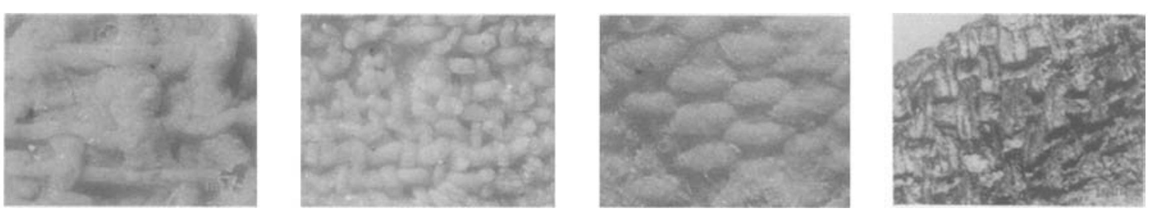
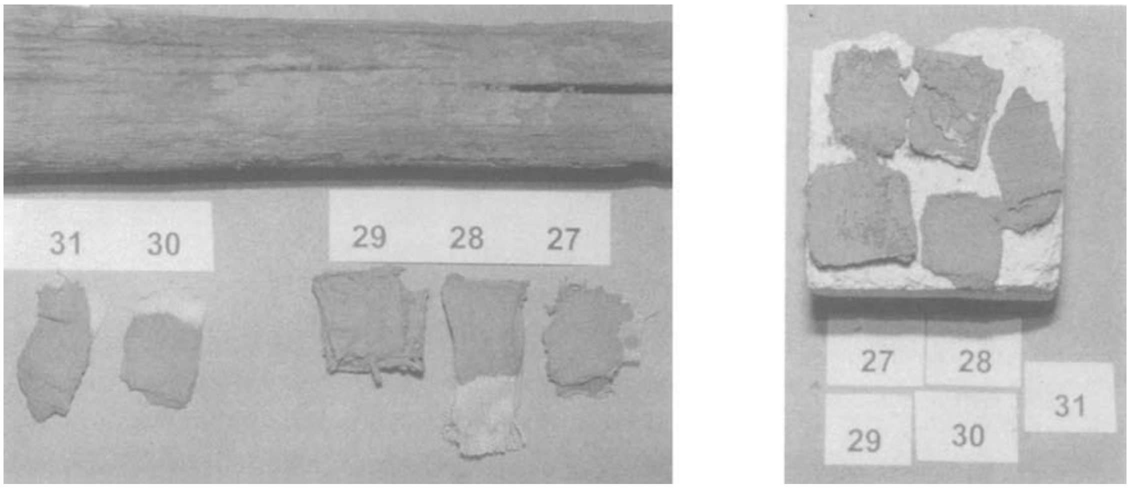


Figure 6. FTIR spectra of thread fiber (CQ 1-11-8, bottom) and comparable cellulosic materials (modern agave , top; cellulose standard, middle), indicating use of a plant fiber.



(a) (b) (c) (d)

Figure 7. (a) plain weave, open, @6x8threads/cm [AG 22A #331 cast]; (b) plain weave, @11x12 threads/cm [AG 22A #331 cast]; (c) plain weave, warp/weft faced, @6x15 threads/cm [AG 22A #331 cast]; (d) plain weave, paired warp/weft, @8x24 (12 pr) threads/cm [CQ 1-11-8].



(a) (b)

Figure 8. Replicas made with cotton cheesecloth (27, 30, 31), linen (28) and burlap (29), and with clay slip; (a) dried and removed from wodden form, and (b) after heating to650 degC. Delamination was most severe in samples 28 and 29.

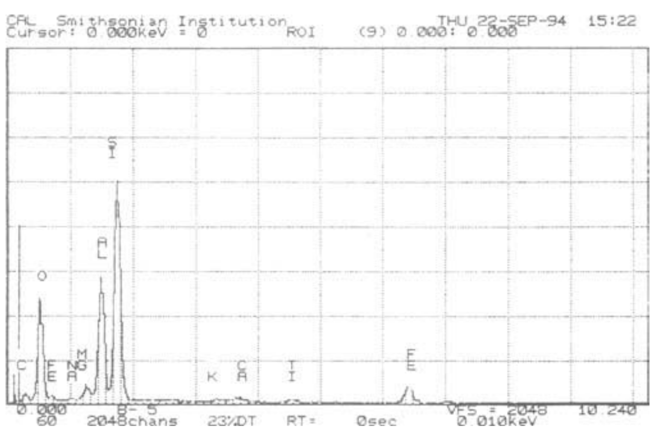


Figure 9. EDS spectrum of matrix elements, comparable to clays [CQ 1-11-8].

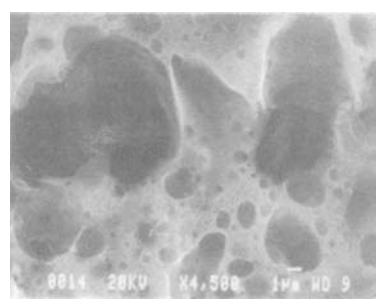


Figure 10. SEM image of glassy matrix material, comparable to fired clay [CQ 1-11-18].

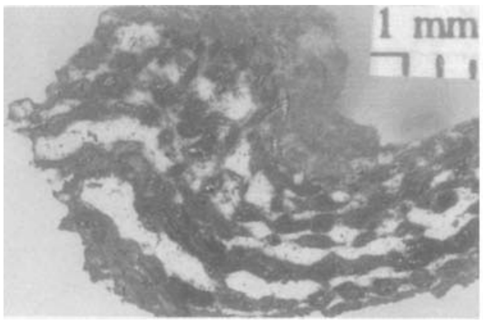


Figure 11. Well-bonded laminate structure in cross-section [CQ 1-11-8]. White matrix layers are visible in the interior.

Figure 12. Concave interior surface with striations, possibly impressions of a wooden mold [AG 22A].

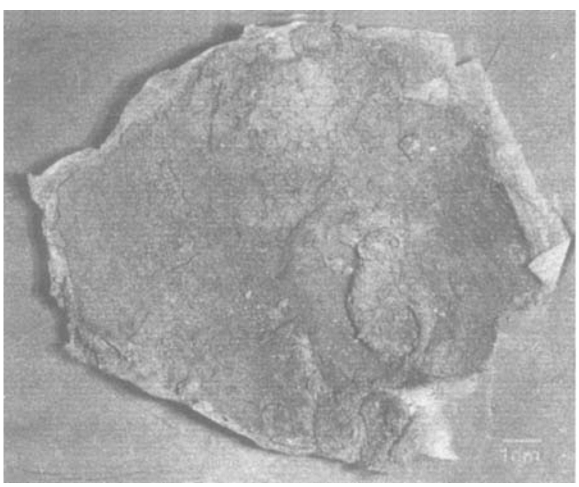


Figure 13a. Interior surface of mask fragment, concave with simple topography [AG 22A #862].

Figure 13b. Exterior surface of mask fragment, with decorative details of folds, incised grooves and red coloration [AG 22A #862].

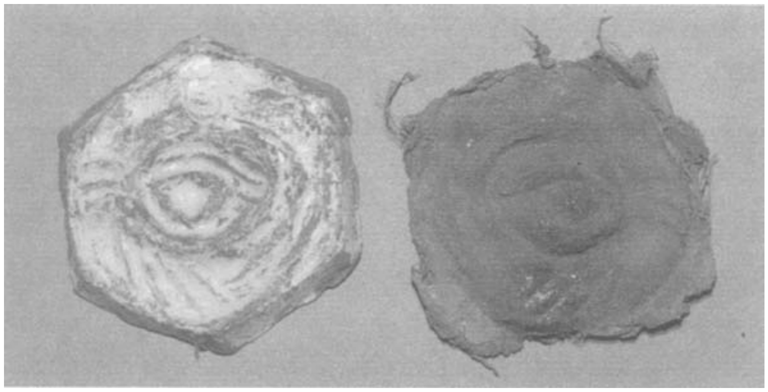


Figure 14. Concave plaster form (mold), and dried replica (obverse). Molded folds exhibit little weave distortion.

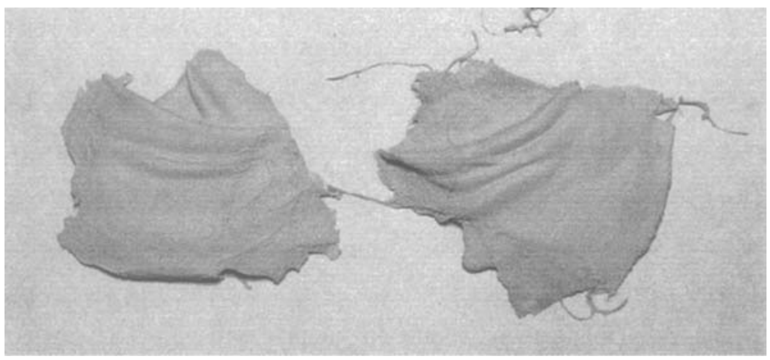


Figure 15. Replicas with freely formed folds, shaped on a simple convex form.

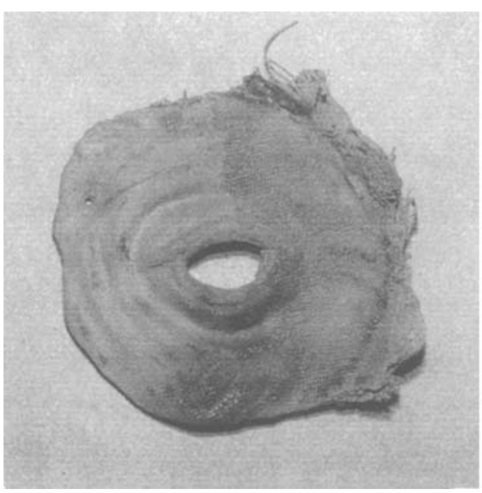


Figure 16a. Replica obverse (same as Fig. 14), with left half finished: replenished surface slip, neat edges, perforation and eye opening.

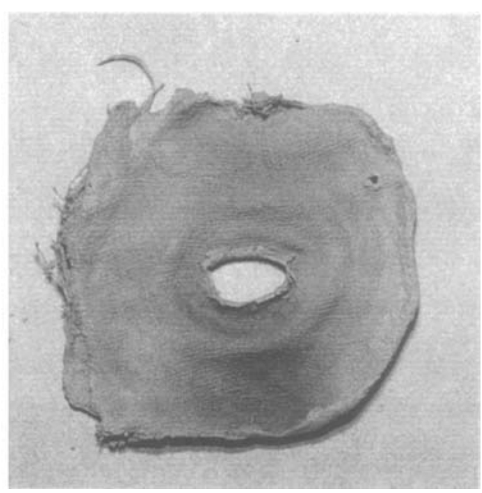


Figure 16b. Replica reverse, with finished edge on the right side.

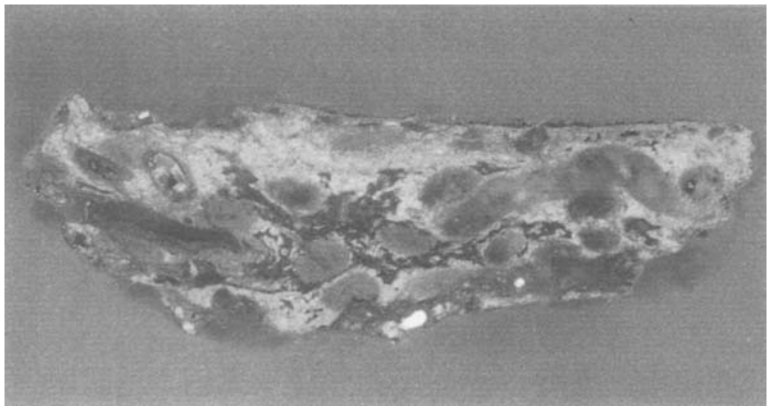


Figure 17. Polished cross-section, showing thin layer of colored slip applied to exterior surface (top) [AG 22A].

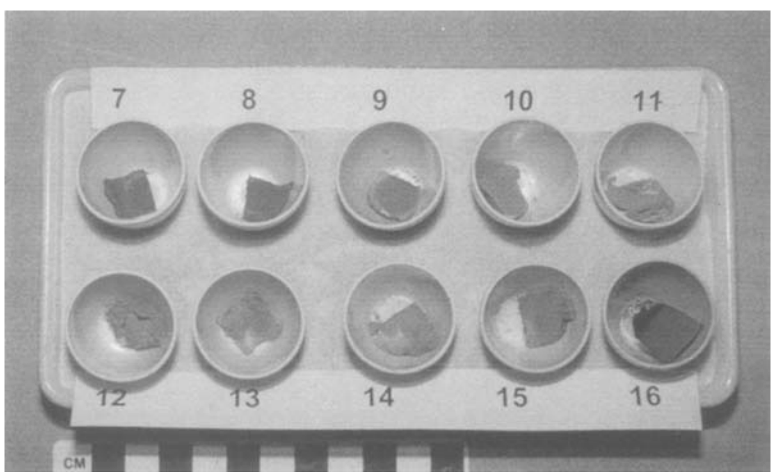


Figure 18. Group of replicas heated to temperatures from 350 degC (16) to 1150 degC (7 and 8) at 100 degC intervals, from right to left.

COLLECTIONS CARE AND CURATION OF DEPARTMENT OF DEFENSE OWNED AND CONTROLLED ARCHAEOLOGICAL ARTIFACTS AND ASSOCIATED ARCHIVAL DOCUMENTS

Thomas James Braun

Many people would be surprised to learn that the Army, Navy, Air Force, and the other branches of the Department of Defense have in their possession voluminous collections of archaeological materials. Many people would perhaps not be surprised that most of these collections are not stored according to modern museum standards. Even worse, these collections are not even up to the curation standards prescribed in numerous federal laws pertaining to federal collections. Fortunately, this problem is being addressed by the Army Corps of Engineers. Addressing this problem requires cooperation not only among the different military branches of the Department of Defense, but also among federal agencies, Native American groups, and many other groups including conservators, curators, archivists, and collection managers.

In the last few decades, numerous Federal and State laws have been enacted which require the branches of the military to thoroughly document archaeological resources which are located on their property. The following table lists some of the more important laws; I will not describe each of these; suffice it to say that these laws are numerous and thorough.

GENERAL LEGISLATIVE AUTHORITY MANDATING ARCHAEOLOGICAL CURATION

1906 Antiquities act (P.L. 59-209)
1935 Historic Sites Act (P.L. 74-292)
1966 National Historic Preservation Act, as amended (P.L. 89-665, 95-515, and 102-575)
1979 Archaeological Resources Protection Act (P.L. 96-95)
1984 Department of Defense Directive Number 4710.1
1990 36 CFR Part 79 (Curation of Federally-Owned and Administered Archaeological Collections)

These laws began what archaeologists today refer to as Cultural Resource Management. For example, when the military is about to build an artillery range, tank proving grounds, or airstrip, they must first survey the land for potential archaeological sites that will be impacted by the proposed military construction.

Before a military installation can use the land, archaeologists must conduct a survey, which is often referred to as a Cultural Resource Management Survey, and this work is generally contracted to private archaeological companies. Usually, the first step is to survey the land by walking over it and looking for artifacts on the surface. When significant artifacts are found, the archaeologists will often conduct shovel tests in which several small circular holes are excavated in the area. These shovel tests penetrate anywhere from a few centimeters deep to several meters deep. If significant artifacts are found in a shovel test, archaeologists will usually assign the location a Smithsonian Trinomial Site Number. This is often a number assigned by the State Historic Preservation Office (or SHPO). The Smithsonian Trinomial Site Number is a more or less standardized method of referring to a specific site, although the system varies slightly from state to state. The Trinomial is composed of the number of the state (from a list of all states arranged alphabetically), followed by usually two or sometimes three letters derived from the county the site is located in, and finally, a sequential number.

After the trinomial is assigned, the archaeologist may then conduct extensive formal excavations in order to better determine the full nature of the site. After all of these investigations are complete, (that is, survey, shovel tests, and excavation), the archaeologist will summarize their findings in a final report which is submitted to the military installation. Subsequently, the military installation will have to decide if they would like to have the site completely excavated, or if it would be less expensive to locate their activities elsewhere.

Federal law stipulates that all artifacts, notes, and associated documentation from the investigation belong to the U. S. government. Unfortunately, often these materials are treated poorly after the completion of the archaeological investigation. The materials may remain in the possession of the archaeologist, or, frequently, they will be warehoused in otherwise unused military buildings, bunkers, or shelters. Often they are packed away into re-used acidic cardboard boxes. Frequently, adequate shelving is absent, and the boxes are stacked on top of each other many boxes high, crushing the artifacts inside (Figure 1). These boxes may be so overloaded with ceramics and stone artifacts that they weigh in excess of sixty pounds. Sometimes they actually approach a spherical shape, and are literally bursting at the seams. Frequently, they have been packaged using poor-quality acidic newspaper or Kraft paper bags. Usually the associated paper records are stored in the same poor conditions as the artifacts. These documents may include oversized maps, survey forms, excavation permits, site forms, excavation notes, correspondence, photographs, draft reports, final reports, and even electronic files. Rarely are these documents housed in archival quality materials, and they are usually incomplete and disorganized.

However, starting about eight years ago, the Department of Defense funded a project for the Army Corps of Engineers to document all of the archaeological collections in the possession of the Department of Defense. I work for this office of the Army Corps. This office is called "the Mandatory Center of Expertise for the Curation and Management of Archaeological Collections, U.S. Army Corps of Engineers, St. Louis District." In Army Corps of Engineers parlance, a "Mandatory Center for Expertise" is abbreviated "MCX" and this term has a precise meaning. This means that all of the different districts of the Army Corps of Engineers are required to follow the directions of the Mandatory Center of Expertise. In other words, all archaeological curation activity within the Army Corps of Engineers is required to be administratively funneled through the St. Louis MCX. There are over a dozen other mandatory centers of expertise, such as the Hydroelectric Design Center, an MCX for the removal and disposal of dangerous buried ordnance, and an MCX for handling hazardous, toxic, and radioactive materials.

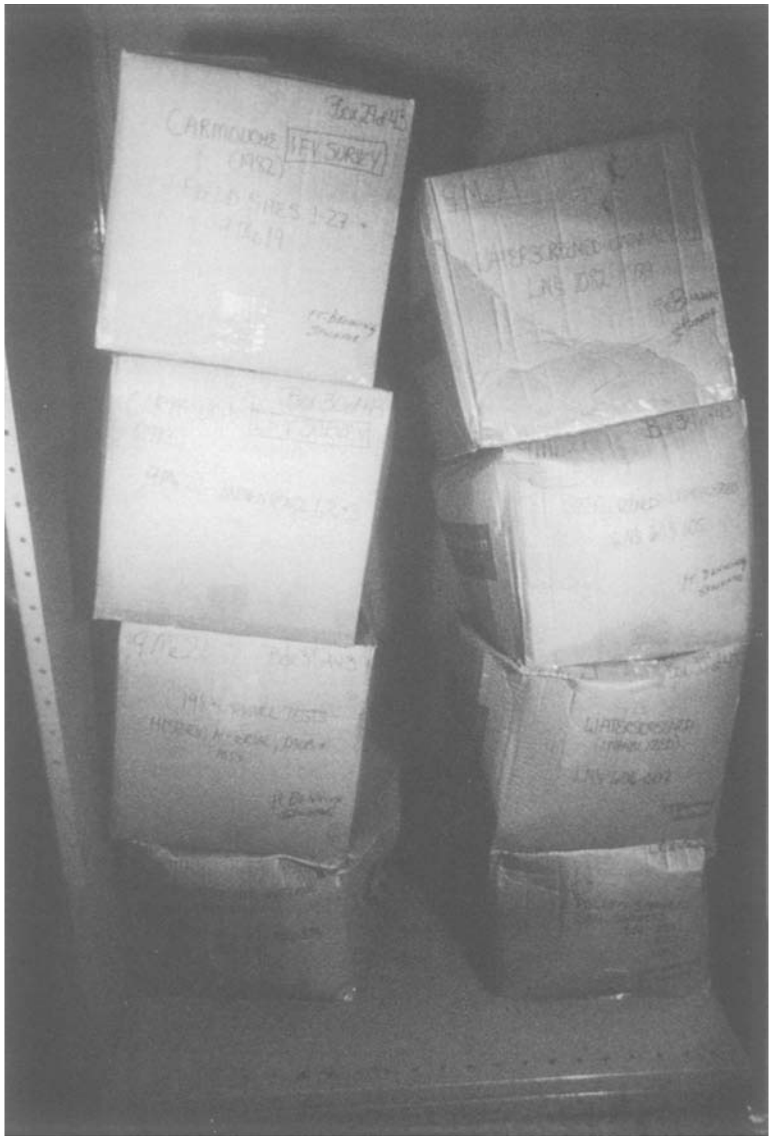


Figure 1. Artifacts in stacked boxes.

The eight-year project being conducted by this office has been assessing all of the archaeological collections stewarded for the Department of Defense, and not surprisingly, this has been a colossal undertaking. This effort has involved a staff of 30 people, including archaeologists, anthropologists, archivists, NAGPRA specialists, architects, and a conservator, myself. These individuals have traveled to over one hundred military installations, universities, and other repositories across the country in order to assess the archaeological collections held there. In June of 2000, this massive eight-year project will come to fruition and the report will be submitted to the Pentagon, and eventually, to Congress. Summarized in this report will be a listing of virtually all of the archaeological collections owned by the Department of Defense, and this report will also include information regarding the size and the condition of these collections. At this point, the best estimate for the size of these collections is over 60,000 cubic feet for all of the various branches of the military. Perhaps 10% of these collections are stored in conditions that approximate modern museum standards, while about 25% are in completely unacceptable condition; the remaining 65% are located somewhere in between (Figure 2).

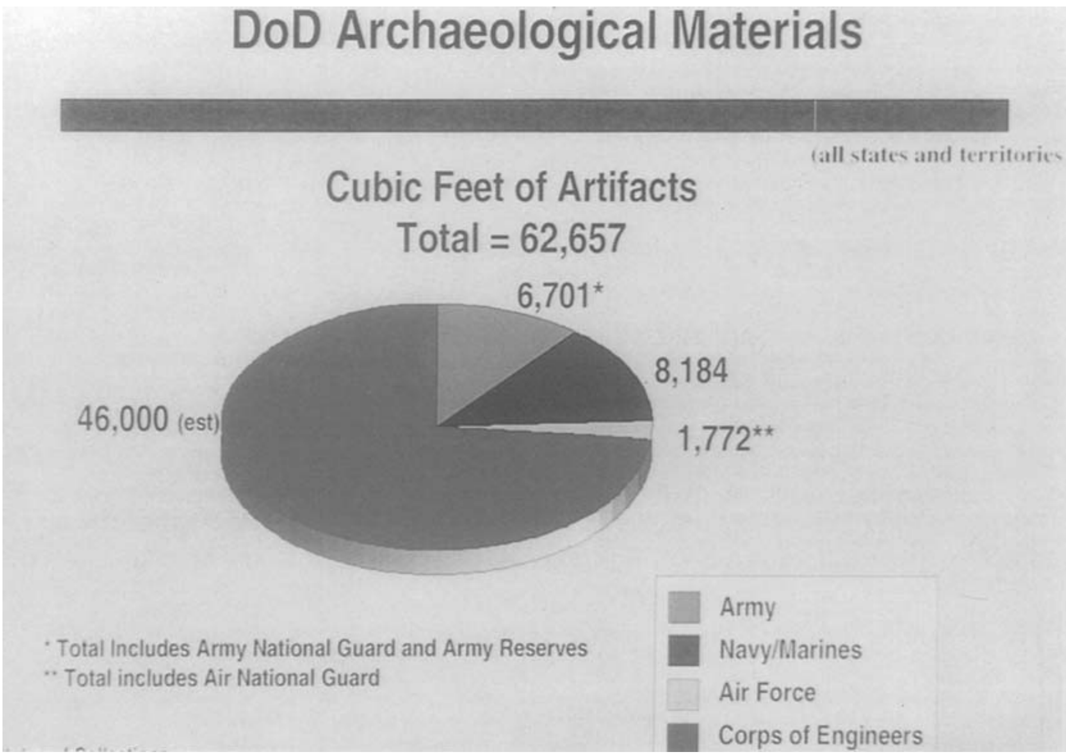


Figure 2. Cubic feet of artifacts owned by the Department of Defense.

Coupled with the final report on these collections is a similar assessment of curation facilities for archaeological collections on a state-by-state basis. This information is important to know, because if the Department of Defense is going to comply with the numerous laws regarding the curation of these collections, it must know about available regional facilities with the capability to adequately curate these collections and provide appropriate standards of climate control, fire detection and suppression, security, integrated pest management, etc.

So, we have the problem: 1) the collections are in bad shape, 2) we know of the solution; there are permanent curation facilities that comply with modern collections storage requirements. So, thirdly, what we need now is someone to process these collections so that they will be acceptable to the permanent curation facilities, many of which have stringent requirements for incoming collections. These basic requirements often include; that the collections must be well organized and thoroughly documented, stored in standard-sized archival storage materials, and that these boxes each weigh no more than 30-40 pounds. After these federal collections are brought up to the standards of the curation repository, the military installations that control these collections can simply turn them over to the repository for permanent and professional curation.

Because the St. Louis MCX has nearly completed the eight-year assessment of Department of Defense collections, they have started several pilot projects in order to pursue this solution. This has been my task. After the Department of Defense identified several collections that had the most critical need of attention, we contacted the facilities where the collections were stored, and made arrangements to transfer the collections to the MCX facilities in St. Louis, Missouri. Here the collections will stay for the duration of several years while they are processed and rehoused. I should note that there are no plans for a central, national repository; eventually, all of the collections will be returned to their state of origin for permanent curation and storage.

Currently, the St. Louis MCX is rehousing two major collections each from different Army installations; Fort Benning in Georgia, and Fort Lewis in Washington State. Both military installations are unique in that they are located on lands with significant and voluminous archaeological resources.

As the collections are received, they are often in very poor condition (Figure 3). One box (Figure 4) became wet from a leak; notice the cardboard has delaminated from exposure to water, the walls have collapsed, and the contents of the box have been crushed by the weight of the boxes stacked on top. Many boxes lack covers or lids, exposing the contents to the accumulation of dust and debris, and often leading to a loss of the arranged order of the artifact bags, in addition to the exposure of light to the labeled bags, which were often written using fugitive inks (Figure 5). The boxes and the bags of artifacts inside are often poorly and incompletely labeled, and usually housed in poor quality acidic materials, using rubber bands, masking tape, fading inks, and bags that tear and mix unlabelled artifacts of different provenience. One collection (Figure 6) had unique problems; the box was an unusual shape, being wide and long, but shallow, and would not be acceptable to most permanent repositories. In addition, the objects were stored on open meat trays made of cardboard or polystyrene, causing easy misplacement of the artifacts. Finally, not all of the artifacts were labeled, so when they were misplaced, the provenience was often lost. The real shock with this collection is that it was formed by the fieldwork used for a Ph.D. dissertation. Today, the student who compiled this collection during his dissertation is one of the foremost professors in North American archaeology and anthropology.

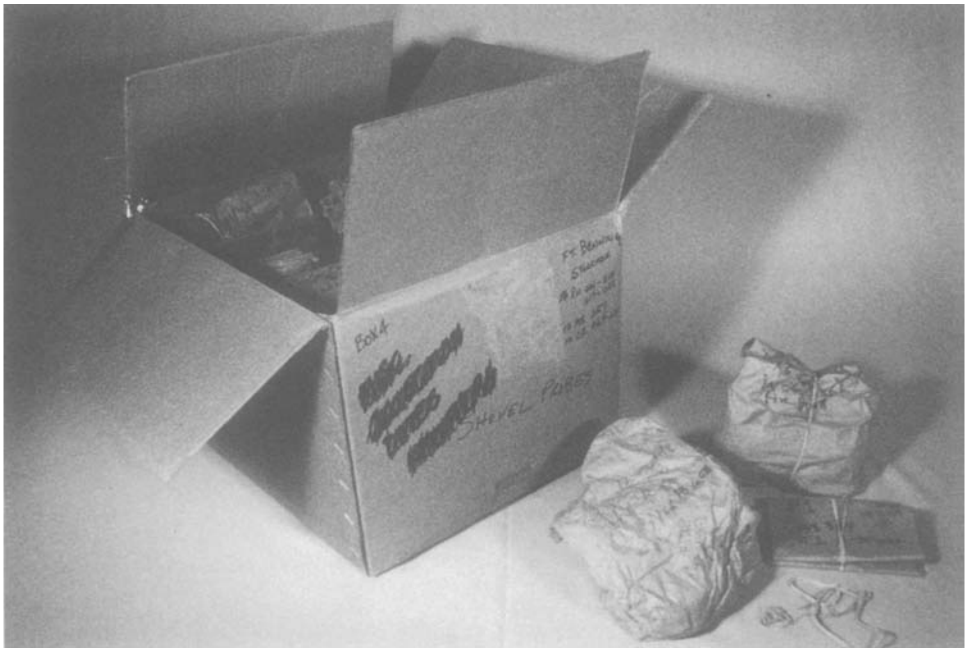


Figure 3. Artifacts as received by storage facilities.

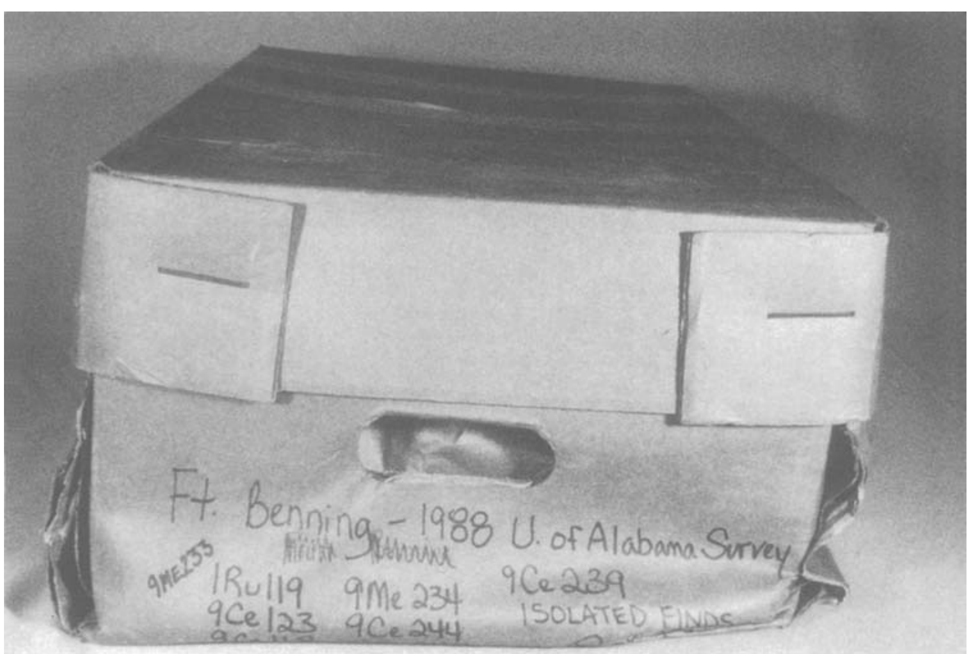


Figure 4. Box crushed by weight of other boxes, and delaminating due to water exposure.

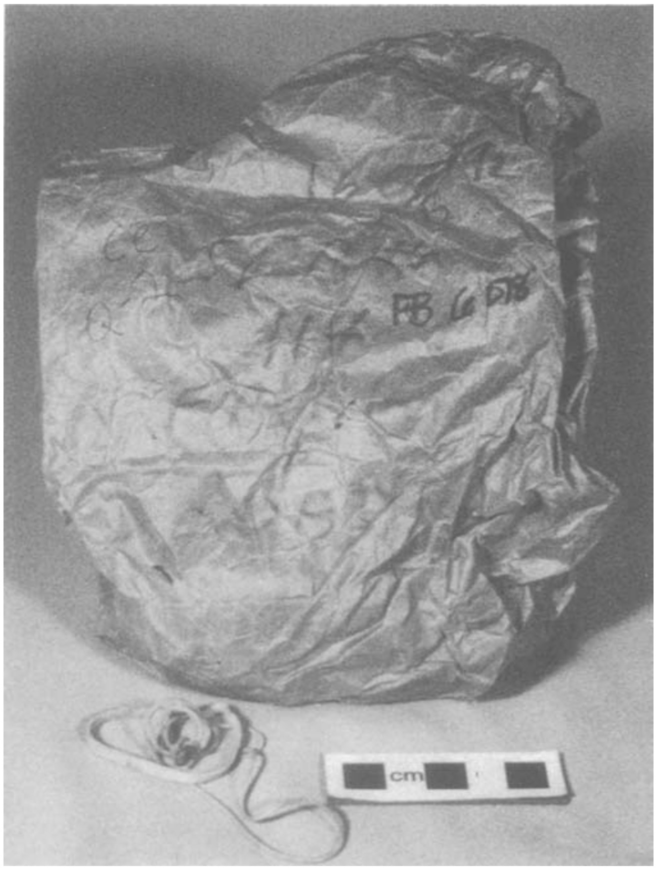


Figure 5.Deteriorating bag and fading labels.

Figure 6. Unlabeled artifacts stored on open trays.

Often artifacts with different storage needs are housed together (Figure 7), in this case, ceramic sherds and lithic tools have been stored in the same bag with bone fragments, friable shell artifacts, charcoal, and several large stones. Clearly, at a minimum, the sharp and abrasive artifacts like the lithics and ceramics should be isolated from the softer, easily damaged charcoal, shell, and bone artifacts. What is especially tragic about this situation is that while many of these collections are not terribly remarkable, there are a great deal of very significant, unique, and important artifacts in these collections. By far the most common artifacts of significance are ceramics and stone projectile points. Some of the most beautiful examples of North American lithic tools were found at Fort Lewis in Washington State. In this area of the country, there is an abundance of raw materials available for making these tools. While rare, we also on occasion find organic remains that have survived within the archaeological context.

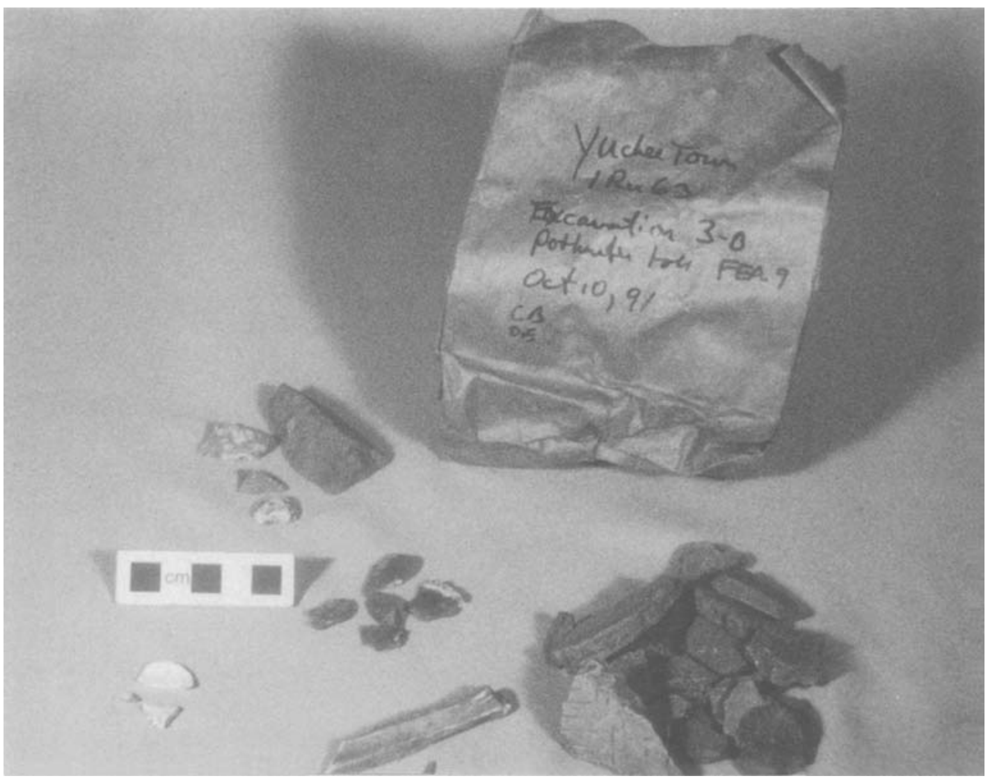


Figure 7. Incompatible artifacts stored together.

The first step in the rehousing process is to remove the bags from the boxes and try to ascertain their proper provenience order. After this is done, the information from the bags (at times supplemented by information available from the final report) is entered into Microsoft Excel, a spreadsheet program. The artifacts are then transferred to a 4-mil polyethylene resealable bag (i.e., Ziploc). This has one advantage in that being clear, artifacts can be examined later without removing them from the bag, thus reducing handling. The original bag (or the part of the bag with the provenience information written on it) is retained, isolated in another plastic bag, and stored along with the artifact. After processing the collection in this manner, all of the bags of artifacts are arranged in order within acid-free corrugated cardboard document storage boxes. Typically, these document storage boxes are the standard size accepted by most permanent curation repositories, whose shelving has been designed to fit boxes of just this size.

After all of the data from the artifacts has been entered into the database, the data is sorted, scrutinized, codified, and where possible, minor corrections made. In our contract with the military installations, we stipulated that while it was cost-prohibitive to individually direct-label each artifact, we would label the outside of the bag, and insert an acid-free paper label inside the bag along with the artifact. We use acid-free, foil-backed, acrylic self-adhesive paper to label the outside of the bags (Figure 8). We use 8 1/2 by 11 inch label stock, on which we can print 15-21 labels per sheet. An identical set of labels is printed on acid-free paper. After the labels have been sorted by provenience, they are printed onto the acid-free paper and label stock, then they are cut into individual labels. Subsequently, the labels are matched with the bags of artifacts. In Figure 8 you see three steps in the labeling process: 1) matching the artifact to the labels, 2) inserting the acid-free paper label in the bag, and 3) applying the foil-backed label to the bag, with the original labels inside. We make sure to laser-print all of the labels, as the ink-jet process has proven to have limitations in permanence.

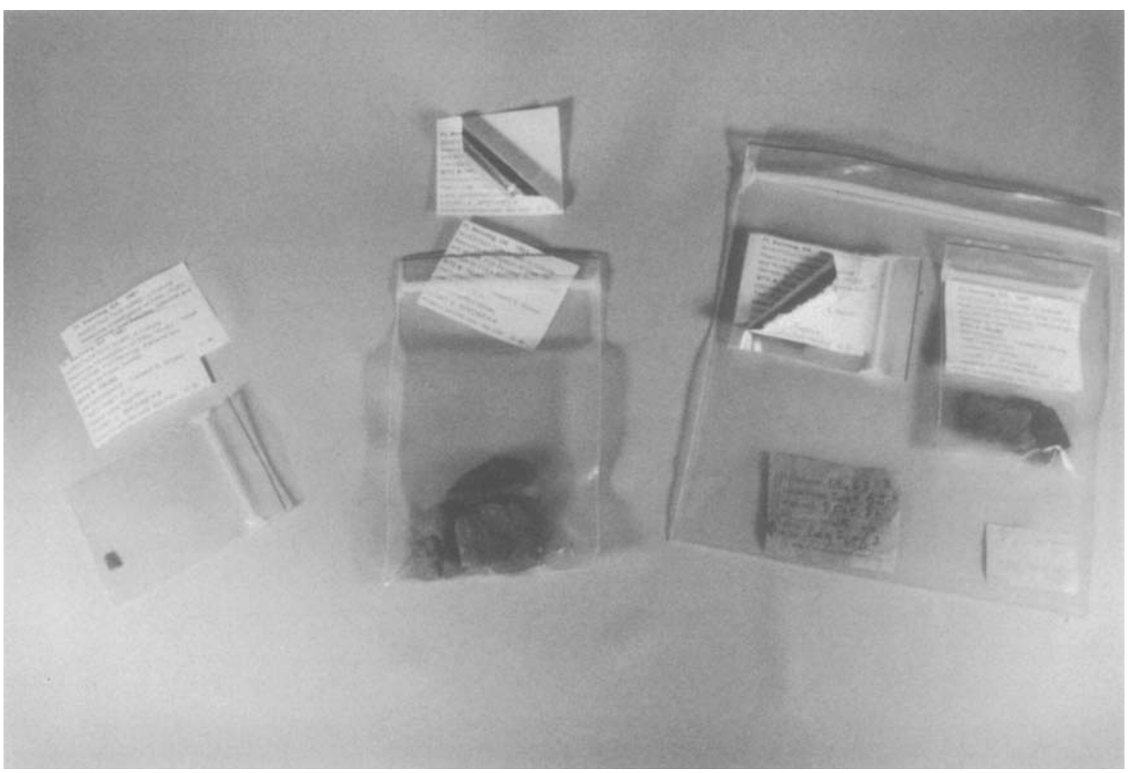


Figure 8. Labeling objects in new bags.

As each collection is rehoused, we generate a short report describing how the collection was processed, and then print out a final hard copy of the database. After bag labeling is complete, a label is completed for the outside of the box, which includes the site number, the name of the archaeologist, a bibliographic citation of the archaeological report, the year the fieldwork was conducted, and a box count, for example, "this is box five out of a total of 12 boxes" in a particular collection.

After the completion of a single collection, there is little left to do for the artifacts but store them until the entire collection is ready to be returned to the state of origin. At this point, we place the boxes in a special holding area where the climate is kept as cold and dry as our air handlers can achieve. This storage facility conforms to the so-called "envelope within an envelope" architectural design recommended for such facilities, making it possible to detect leaks before they can cause damage, and helping to provide excellent and stable climate control. After the collections are returned to the appropriate military installation, they will eventually be housed in a non-governmental curation repository which will receive periodic payments to curate the collections in perpetuity. We will provide a compilation of all of our final reports to the military installation and the curation repository upon completion of the entire collection. With the completion of our project, we will supply our report, in addition to a CD-ROM copy of the electronic database files, so that the collections can be better managed and administered in the future.

Issues related to the Native American Graves Protection and Repatriation Act (NAGPRA) are also a large part of our work. Typically our contract requires us to separate out any human remains for return to the military installation for potential repatriation to appropriate tribes.

My time at the St. Louis MCX is spent mainly working with the artifacts, and in figure 9 you see a collection before and after treatment. However, the associated archaeological archives are also processed at the MCX by a team of archivists, and Figure 10 shows a collection of papers before and after treatment. I assist them with minor dry surface cleaning and mending of torn documents, but most of the processing is done by the archivists. In Figure 10 a box of disheveled and disorganized files has been sifted through, transferred to acid-free folders, each labeled with a graphite pencil, and arranged in chronological order, inside an acid-free corrugated cardboard document storage box. The archivists produce finding aids which will greatly assist researchers working with these collections.

In conclusion, the Corps of Engineers has been processing collections in this manner for a little over two years, and we are about to finish our second and third complete collections. There is a tremendous amount of work ahead of us, and the processing of all of these collections on a nationwide scale could encompass several decades and many millions of dollars. Ironically, while the Department of Defense spends only a tiny fraction of its huge budget on this type of work, this tiny fraction amounts to an enormous amount of money by the standards of our field. At the MCX we are still learning from our mistakes and streamlining our procedures, but the future looks bright for us to continue on this track.

Figure 9. Object collection before and after treatment and rehousing.

Figure 10. Object records before and after treatment and rehousing

Supplies

Resealable plastic bags are supplied by Chiswick Incorporated, 1-800-225-8708
Foil-backed self-adhesive laser labels are supplied by University Products, 1-800-532-9281
Acid-free corrugated document storage boxes are supplied by the Paige company

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DIGITAL IMAGE ANALYSIS IN MICROSCOPY FOR OBJECTS AND ARCHITECTURAL CONSERVATION

Elizabeth Goins and Chandra L. Reedy

Abstract

The advent of high-speed computers and comparatively large memories, coupled with digital microscope cameras, has brought about a revolution in computer-assisted image analysis. New software can ease the pain of previously laborious methods of thin-section and cross-section analysis. Image analysis not only speeds traditional microscopical methods, such as point counting, but also improves accuracy. By using image analysis software, a job that would have taken hours by traditional methods now takes only seconds. This increase in speed allows more time for additional investigations, such as examination of textural relationships between particles. The great accuracy enabled by area analysis of thin sections also allows more detailed comparison between samples in technological studies, and facilitates new tests of sampling issues and statistical accuracy.

Increased accuracy is now possible in examination of materials characteristics such as percentage of aggregates, pores, temper, or specific minerals; pore or grain size; grain shape; and other important features of petrographic thin sections. The increased accuracy and the ability to conduct more detailed and comprehensive studies can positively impact characterization, analysis, and interpretation of composition, technology, provenience, deterioration, and preservation. In this paper we explore new applications of image analysis technologies to the microscopical examination of a cross sections or by petrographic thin section analysis of low- and high-fired ceramics, unfired clay artifacts, stone objects, and historic mortars.

1. Image Analysis

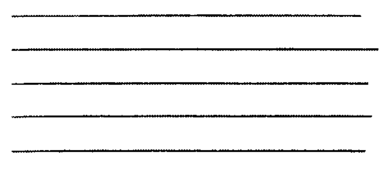
Image analysis refers to the application of computer processing to aid in the measurement or quantification of features visible within an image. Typically the images are photomicrographs of sections either in transmitted or reflected light. Images from scanning electron microscope/ backscattered electron imaging are also analyzed by image analysis. In this paper all image analysis was conducted using the Image-Pro Plus package from Media Cybernetics..

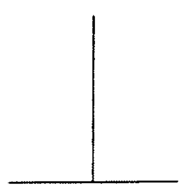
The major advantage that image analysis has over traditional visual estimations is that it facilitates efforts to characterize, classify and compare images by using numerical values. It then becomes possible to accurately measure features of an element or number of elements, such as length, width, distance between features, roundness, size distribution and clustering of features, among others.

Image analysis was developed from the traditional methods of modal analysis, like point counting, and therefore must hold to the same rules. Modal analysis, commonly used in geology for estimating the relative proportions of phases in a rock, is based on the De Lesse (1956) relation which states that the ratio of the area occupied by a mineral (A) to the area occupied by all minerals (the total measurement area) is a consistent estimate of the volume percentage of mineral A in the rock.

The problem with the traditional method of modal analysis is that the estimates can be biased by optical deception. The human eye is very effective in some areas of visual comparison but is somewhat poor in its ability to determine quantitative information like length and area (Jähne 1995). With the advent of inexpensive, powerful personal computers, the development of image analysis as an effective tool became feasible so that more accurate information could be pulled from the sample.

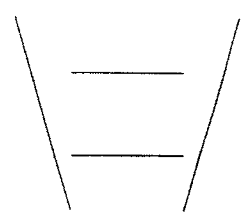
It is easy to trick the human eye in some cases. The following illustrations show some of these effects. In the figure to the right, a number of parallel lines are shown. The length of the lines varies by up to 5%, and, in this case, it is easy for our eye to determine that they are of different lengths.

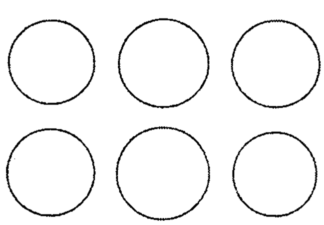




This illustration shows the influence of the direction of the lines. Both of these lines are the same length, yet to our eyes the vertical line appears longer than the horizontal.

Perspective: The two parallel lines in the center are of equal length, but our eyes interpret the upper line as being longer than the lower line.





The eye is a poor estimator of volume or area. The area of the circles to the left varies by up to 10%, yet it is difficult for us to determine much difference - let alone by what percentage they vary!

Traditional modal analysis attempted to compensate for the inability of the human eye to quantify features by a number of different methods. In the beginning DeLesse based his work on areal ratios. He would trace the minerals of a section onto wax paper then transfer the design to tin foil which was then cut out and each mineral component was weighed. The time it would have taken to accomplish the measurement for one section must have been enormous. And, the possibilities for error must have been extreme.

Eventually, it was found that by measuring the length of each mineral an estimate of relative ratios could be found. This is called the lineal traverse (Figure 1) where a mechanized stage moves the sample over evenly spaced traverses.

$$\text{Relative amount of mineral (mode)} = \frac{\text{Length of the mineral traversed}}{\text{Total length traversed}}$$

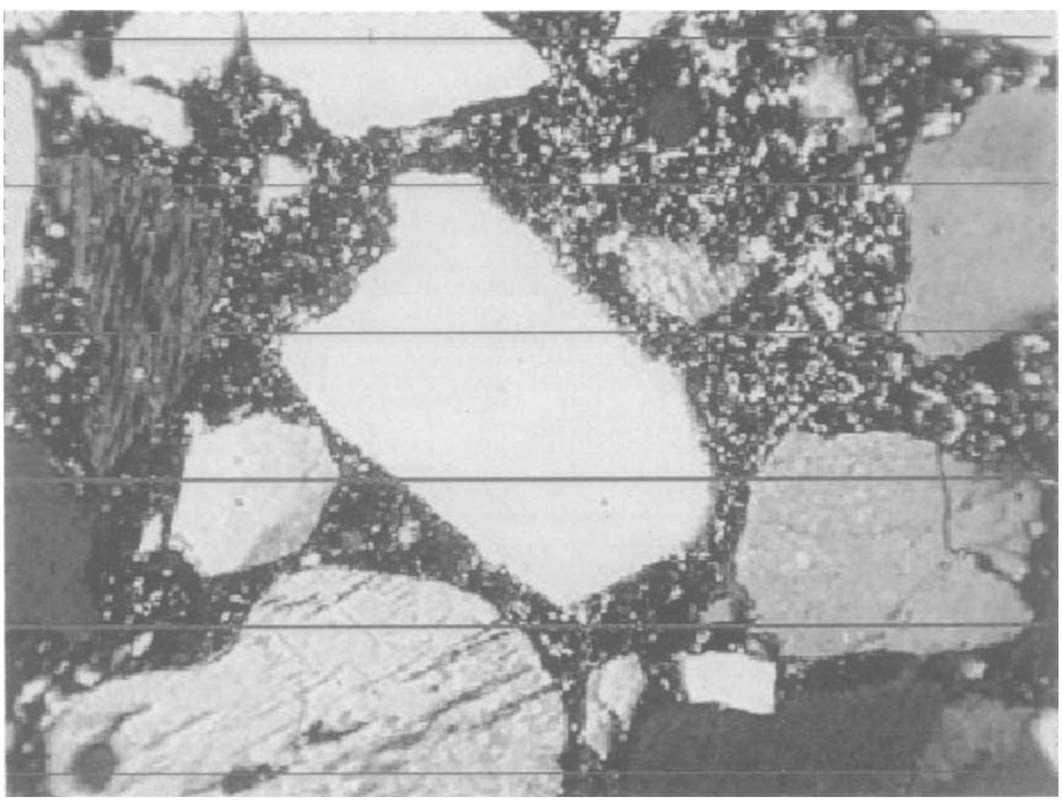


Figure 1: A polished cross section of a lime mortar and aggregate. The lines superimposed over the image would measure the relative areas in the lineal traverse method (distance separating the traverses has been compressed for illustrative purposes).

Finally, the point counting method developed that is most commonly used today. This technique estimates the relative proportions of phases by identifying and counting minerals located at grid intersections or points (see Figure 2).

$$\text{Relative amount of mineral (mode)} = \frac{\text{Number of times a mineral is found at grid intersections}}{\text{Total number of points counted}}$$

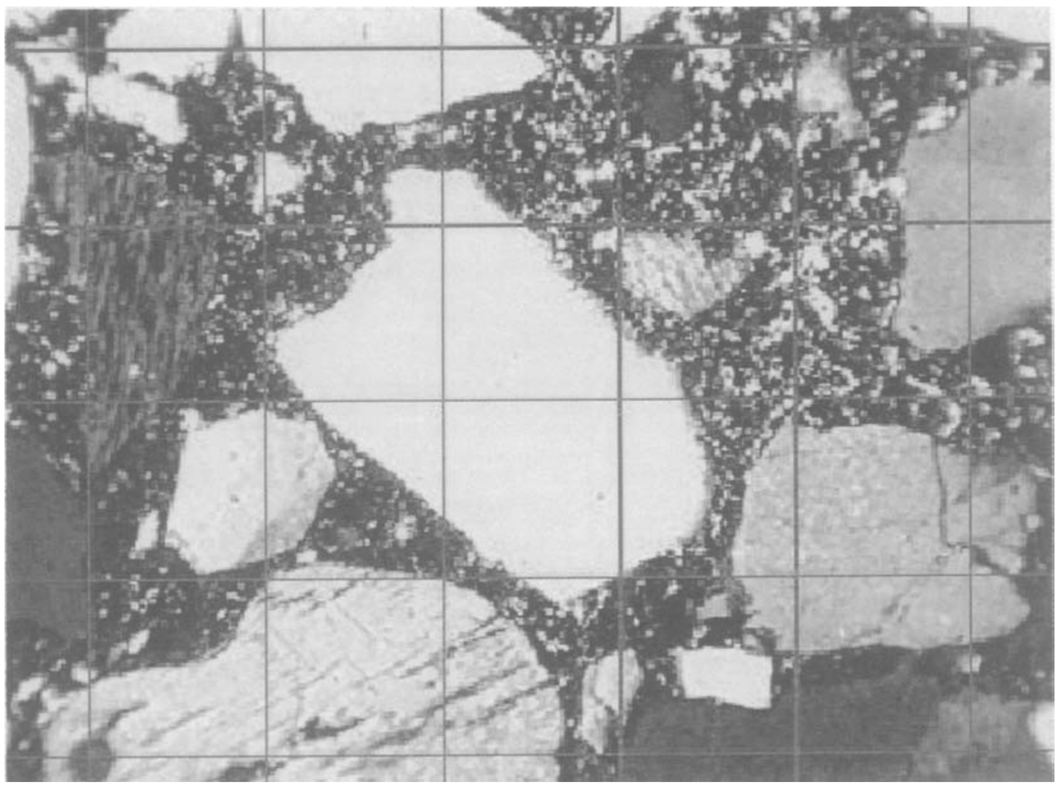


Figure 2: The same polished section as in Figure 1 with a grid superimposed over the image for the point counting technique. Again, distances between parallel lines have been compressed for illustrative purposes.

Areal measurements (Figure 3) could not be reliably, or easily, carried out until the advent of personal computers and image analysis software. The software analyzes the image and picks out areas of different intensity or color values. This makes contrast within the image to be analyzed an important issue. In this figure we were able to pick out grains within a particular size range and contrast. This image is the same as used for the point and lineal traverse illustrations. Notice that the software did not pick out the darker grains along the edges. Once the features or minerals of interest can be separated from the matrix then we can begin to try and characterize the material in more detail.

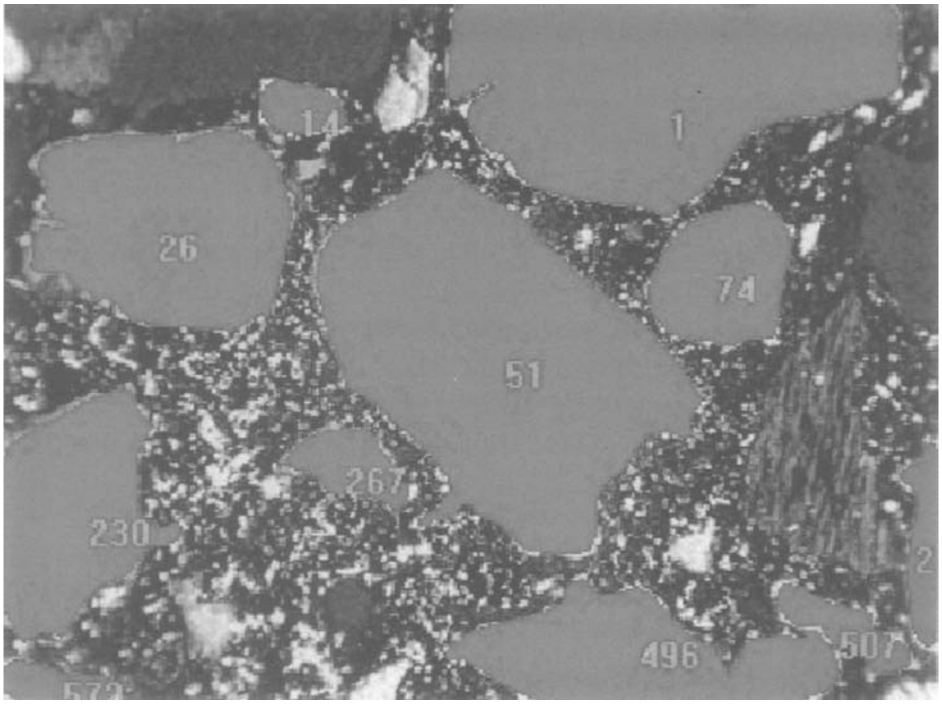


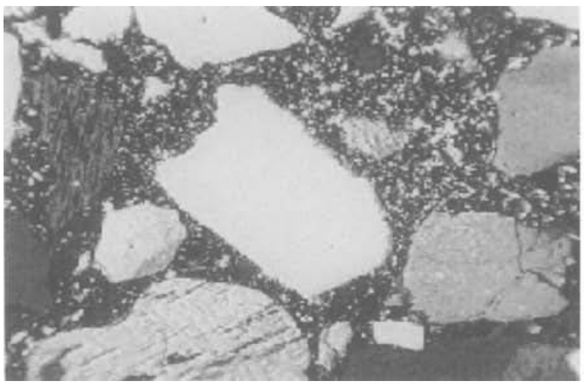
Figure 3: The polished section of Figures 1 and 2 again but the sand grains are highlighted for measurement within Image-Pro Plus.

One major issue that is of concern for any method of modal analysis, be it point count, lineal traverse or the areal analysis by image analysis, is statistical validity. It is imperative that enough points or grains are examined to give the analysis statistical validity.

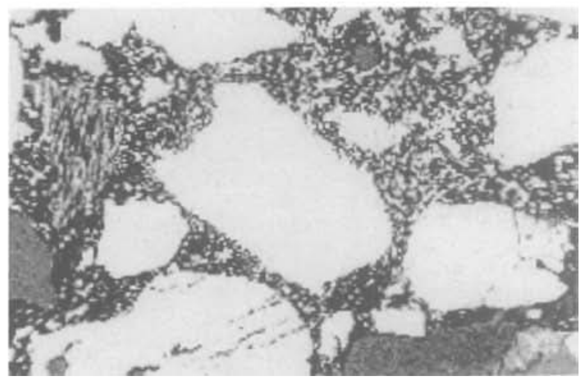
This begins with the design of the experiment; that is, the samples must initially be selected so that they are truly representative of the material being studied. The samples selected then must be large enough so that they can include any variations that may be present.

The sample size and number of grains studied will vary with the material. In particular the grain size will have a great impact. The bigger the particle sizes the larger the sample required. Also, the amount of that phase present within the material will influence number of grains counted. Obviously, if the phase of interest is a minor phase, present in low amounts, more grains will have to be counted overall to give a high enough confidence level.

Assuming that the sample is statistically relevant, getting the image analysis software to work often requires enhancement of the image. This means that the initial analyses of the material can be time consuming until a reliable method of enhancements has been found. In the image below we would like to measure all the grains. However, they are different shades of gray and the software would have difficulty "thinking" that they were all the same phase. There are a number of ways to compensate for this. One way would be to take a series of measurements within each gray or intensity scale and then add the results together. However, software like Image-Pro Plus allows one to manipulate the image. In this example we have simply upped the image contrast and brightness.



4a: Polished section.



4b: Polished section (a) with increased contrast and brightness.

There are a number of different filters and algorithms that may be applied to the images in order to enhance features of interest. The filter in the example below (Figure 5) emphasizes all the edges and ignores particle masses.

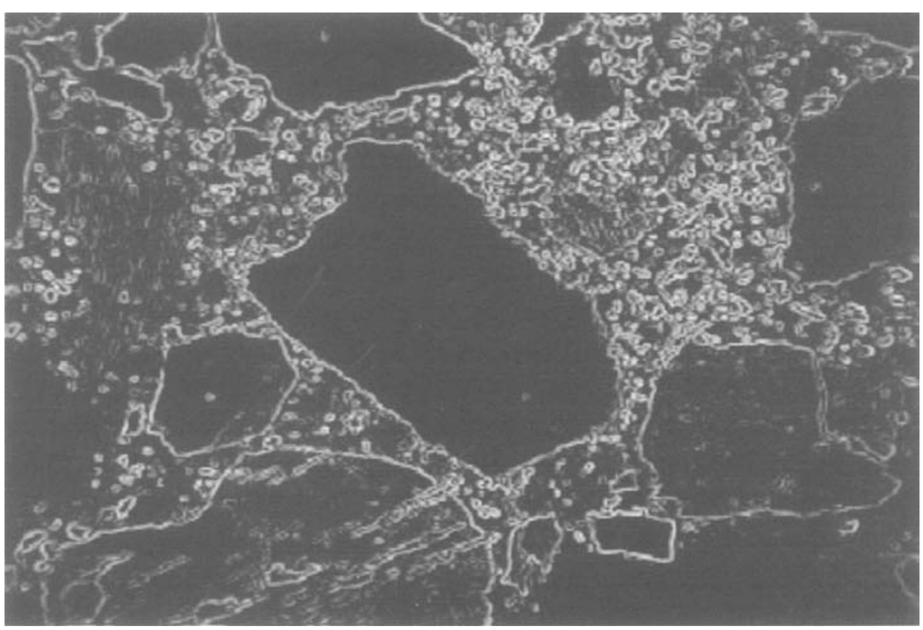


Figure 5: The polished section (as in previous figures) with an edge filter applied.

Once the features of interest can be separated reliably by the software, the analysis can begin. In the example below (Figure 6), the first step was to define an area of interest by simply drawing a rectangle around the grains we wanted to study. The grain boundaries were determined and then data was collected on the perimeter, roundness, length of axes, etc., of each grain.

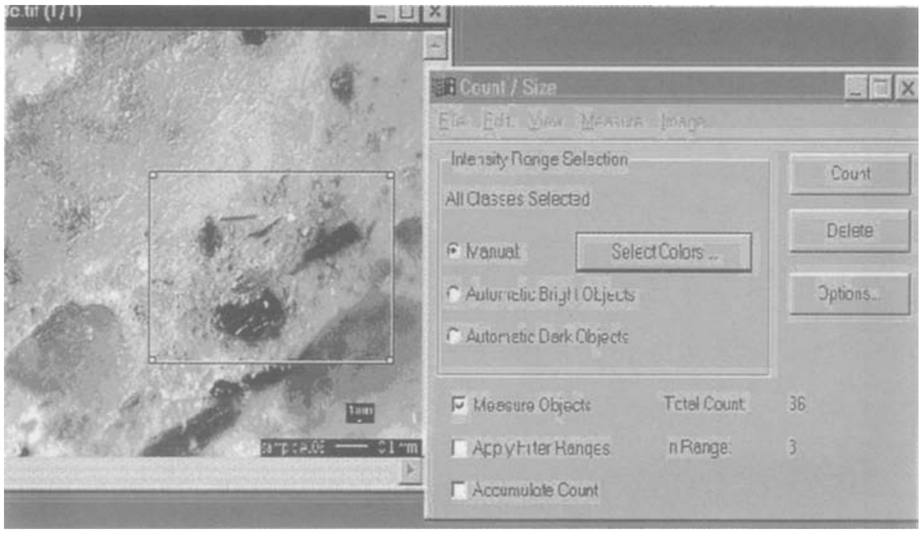


Figure 6: A polished section within the Image-Pro Plus environment. The grains to be studied are outlined and then selected for measurement.

The software nicely determines the area of the grains for the measurement of many of the features (Figure 7).

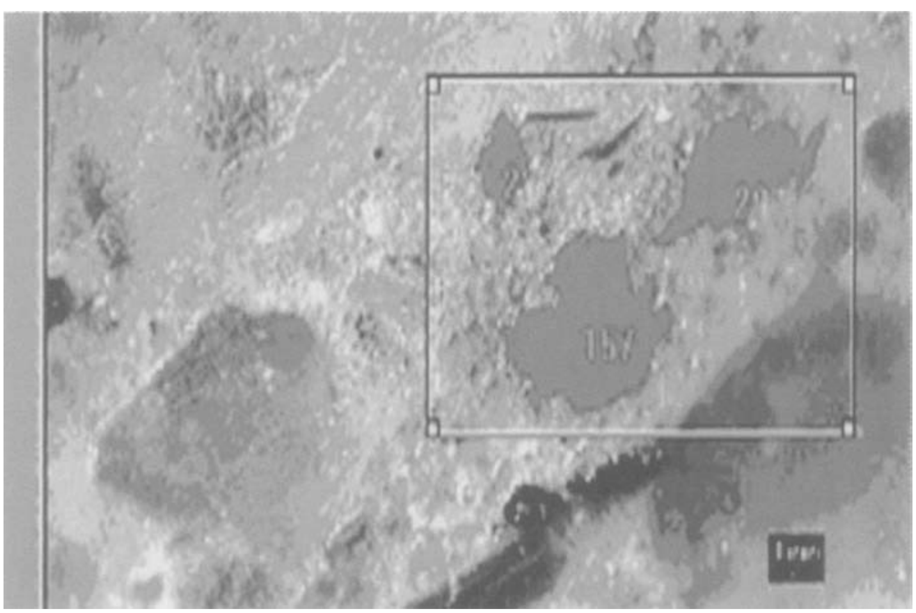


Figure 7: Image Pro-Plus has determined the area of the grains to be measured.

Once the data is collected, which takes only a few seconds, it is easily exported into a spreadsheet like Excel (Figure 8).

Obj.#	Axis (major)	Axis (minor)	Diameter (mea	Radius (max)
28	0.19905038	0.14419197	0.16504091	0.11242238
29	0.46274218	0.22671236	0.32958165	0.29607078
157	0.47132242	0.35698923	0.39760616	0.2755248

Obj.#	Size (length)	Size (width)	Perimeter	Radius Ratio
28	0.22164917	0.15682983	0.60503036	1.7304498
29	0.56881714	0.29718018	1.5529007	3.6174127
157	0.51876068	0.38704681	1.717976	2.467848

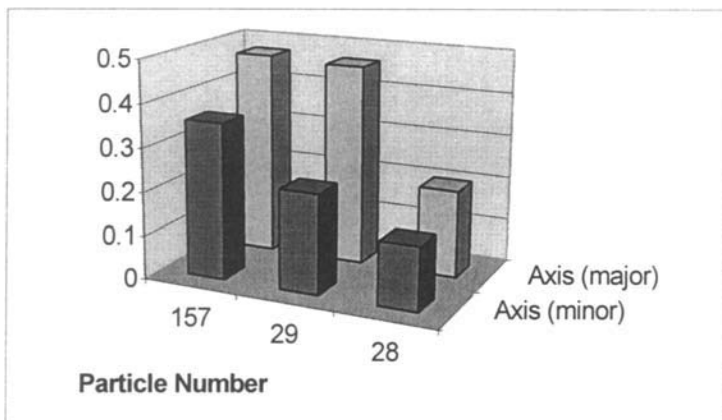


Figure 8: Results from Image-Pro Plus analyses output to Excel.

2. Conservation Research Applications

One of the most obvious uses for this procedure is to determine the thickness of layers with great accuracy. In this example we have defined a number of different layers. The example (Figure 9) shows a thin foil of copper over a mortar substrate. The surface layer runs along the very right edge. The foil is being pulled apart from weathering and the crack is outlined and measured in the center of the foil layer on the right. We are able to measure both the lengths of the traces and the distances between them. A number of points are measured along each line and the minimum; maximum and average distances are easily determined (these are given by the CT values in the chart).

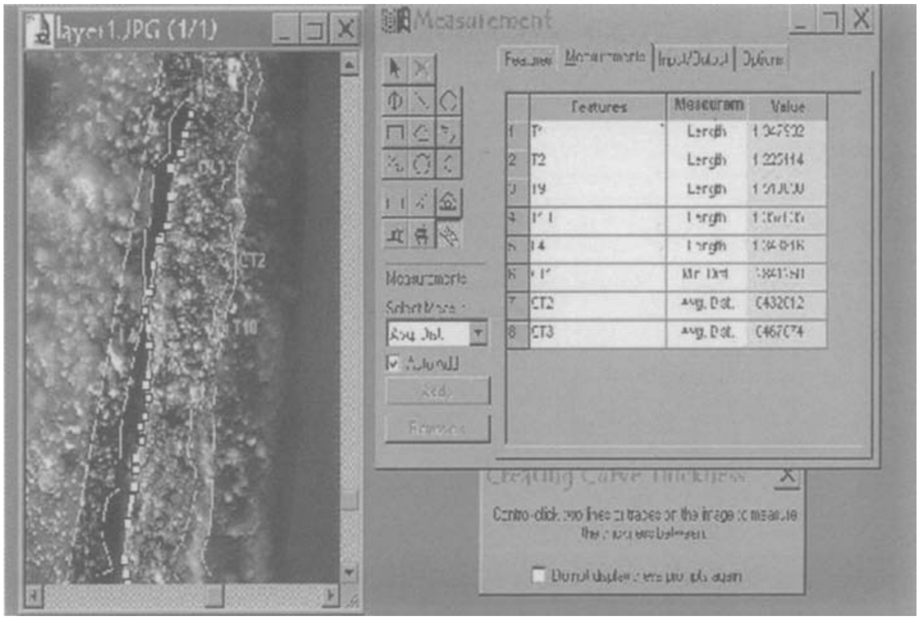
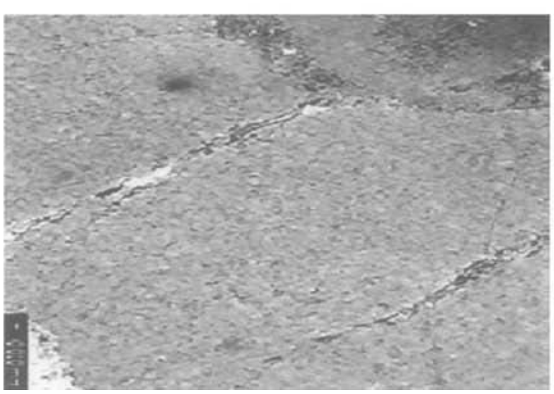
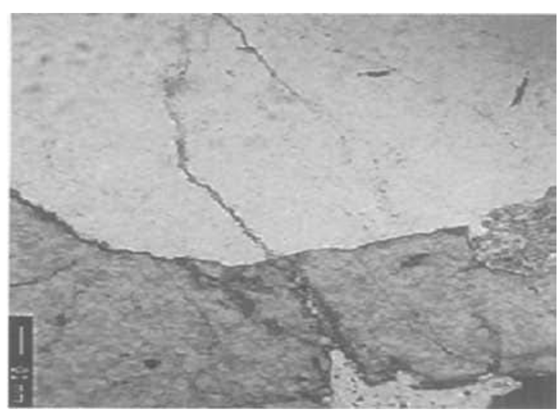


Figure 9: Measuring thickness in Image-Pro Plus.

One example of the usefulness of image analysis in studies of objects or architectural materials is in studies of the deterioration of stone. In granite, for example, the presence of microcracks in quartz grains (Figure 10a, b) has been shown to be related to degree of weathering (Dearman and Irfan 1978; Ordaz et al 1978; Rainey and Whalley 1994; Hernandez 1996; Molina et al 1996). Typically, researchers want to count the number of microcracks found while moving along a linear transverse area in a thin section of standard size. The overall length and average fracture length is also computed. Multiple thin sections, usually at least 5, are analyzed to characterize a stone or to check for differences between external surfaces and interior samples. For relatively wide cracks, such as the ones in Figure 10a, the width of the crack may also be assessed.



10a. Two microcracks within a quartz grain in granite; both are relatively wide.



10b: This microcrack extends into multiple grains and is developing numerous offshoots.

Other variables that are often recorded include whether the cracks are located within single grains, or if they are intergranular, extending into adjacent grains, as on Figure 10b. The fractal character of the crack is also considered an indication of severity of deterioration -- as the lower crack in figure 10b has begun developing many tiny crack offshoots from the original crack. This is often found where there are intergranular cracks and multiple cracks.

In contrast, grains with mostly single isolated microcracks (Figure 11) tend not to have yet developed many offshoots or feathering characteristics.

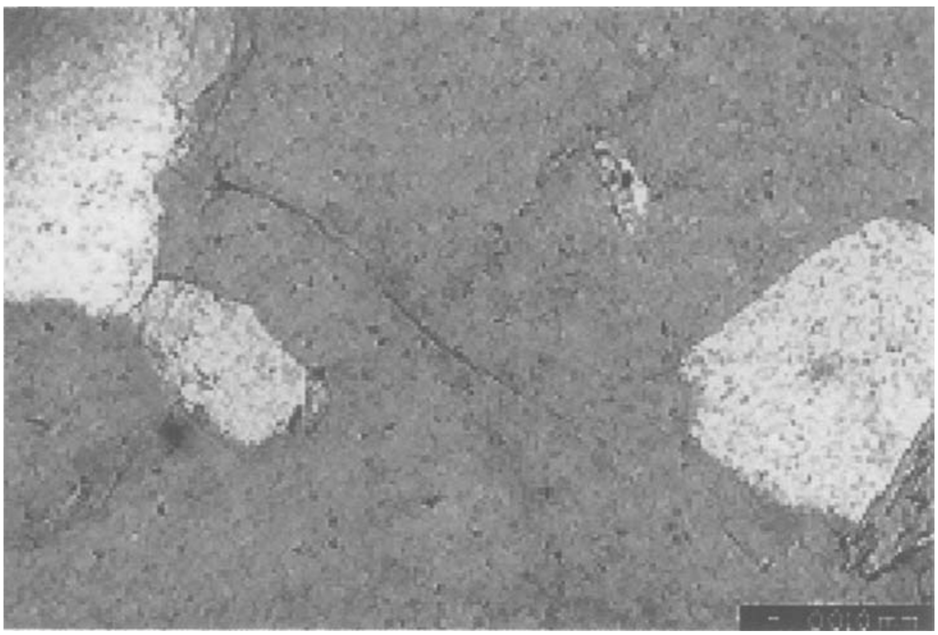


Figure 11: Quartz microcrack without offshoots or feathering.

The tedious task of trying to accurately measure the length of many curving microcracks is made much easier by digital image analysis. But first each image must be calibrated so a length in a specific unit, such as microns, can be calculated, rather than simply the number of pixels measured. This is done by including a scale bar for each magnification , then using that bar to save the spatial calibration for use in all calculations.

Using a tracing tool, we can trace along the crack we want to measure (Figure 12), here labeled T1. The length will be automatically calculated in whatever units we used for the calibration. The ease of this method is especially apparent for samples with more complex cracking patterns.

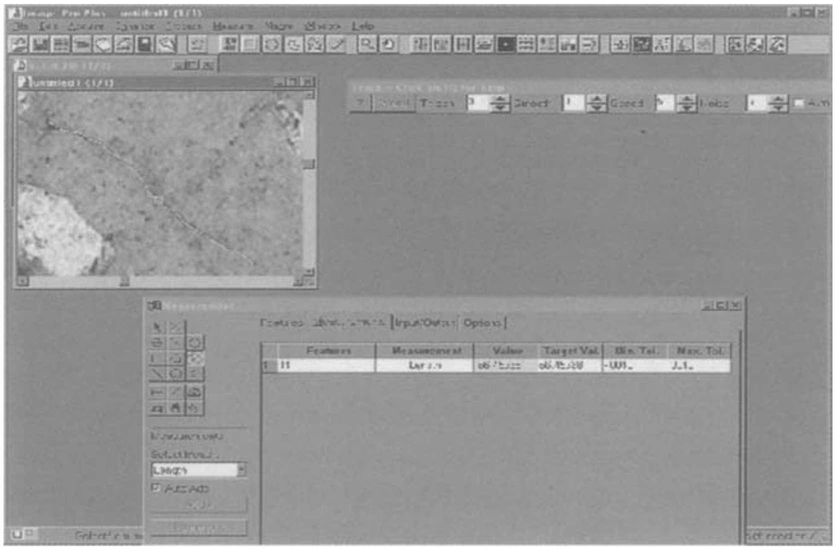


Figure 12: A tracing tool is used to measure the length of a curving microcrack in a quartz grain within granite.

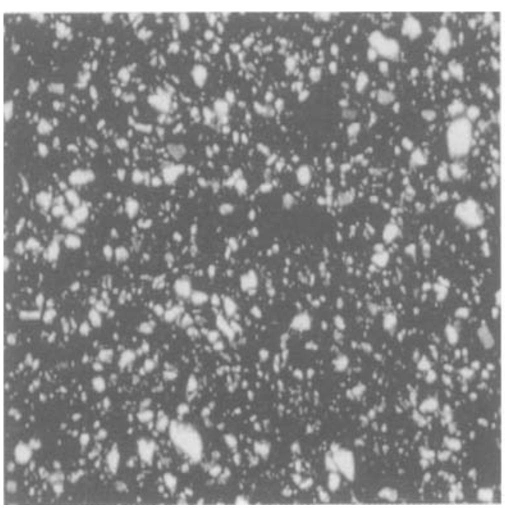
Another example with stone is in measuring deterioration layers, as an assessment of weathering. In Figure 13 we have volcanic tuff with an outer layer of severely altered material, very different in appearance from the layer below. The method of measuring thickness of the layer is the same as we saw for the corrosion layer above. Lines are traced along the two edges of the layer, T1 and T2, and the distance between them measured. We are generally interested in not only the average width, or distance between the two lines, but also in the minimum and maximum distance. This process allows us to examine variation in the outer weathering layer (CT) that would be very tedious to do by traditional methods using a micrometer to take each individual measurement by eye.

Figure 13. Measuring the weathering layer on a volcanic tuff specimen.

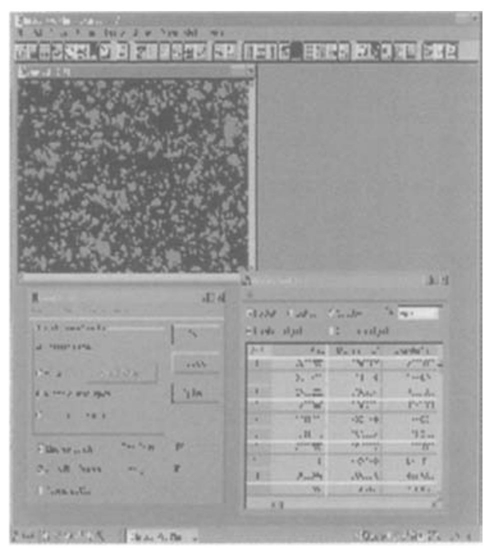
With thin sections of ceramic materials, there are many things we look for depending on the goals of the study. Thin sections may be used as part of an assessment of deterioration, or for investigation of the range of technological choices made by the producers, or for provenance studies (grouping objects by a region of production or a workshop, based either on geological characteristics of temper additives, such as shape of quartz grains, or by technological characteristics, such as the amount of temper added). In addition to extremely tedious point counting, determining the amount of temper additives has often been done by visual estimation, using diagrams to try to visually determine the percentage of components such as quartz sand, shell, organic tempers, or pores left from burnt-out organic temper. The British Museum published very detailed versions of the visual estimation diagrams (Matthew et al 1990), but still it is extremely difficult to be very accurate, thus making it difficult to use such criteria to distinguish between workshops.

In Figure 14a, a crossed-polarized image of a ceramic thin section (x20), we want to determine the percentage of quartz and feldspar grains of the sand temper (the white and gray spots) within the clay matrix (the dark background area). It is also useful to characterize the size and homogeneity of temper materials.

In this case the bright objects were selected for counting. If some seem to have been missed, the filter could be changed to include anything slightly gray; or certain mineral grains (such as small rectangular mica grains) could be eliminated from the count.



14a: A ceramic thin section (x20) in crossed polarized light, showing white sand grains (mainly quartz and feldspar) within a dark clay matrix.



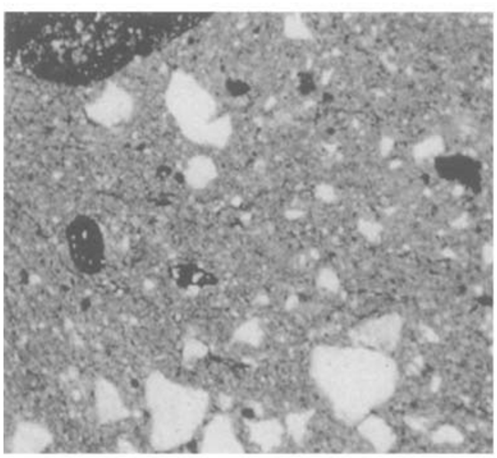
14b: Using Image-Pro Plus, the bright sand grains were highlighted for counting. The area of the sand temper is given as a percentage of the total area of the image.

A wide variety of measurements can be taken. In Figure 14b we are looking at area. The area of each of the 881 counted objects is given, along with their minimum and maximum diameter. Any particular grain can be examined more closely if needed. The total area of the counted sand grains is then given as a percentage of the total area of the image.

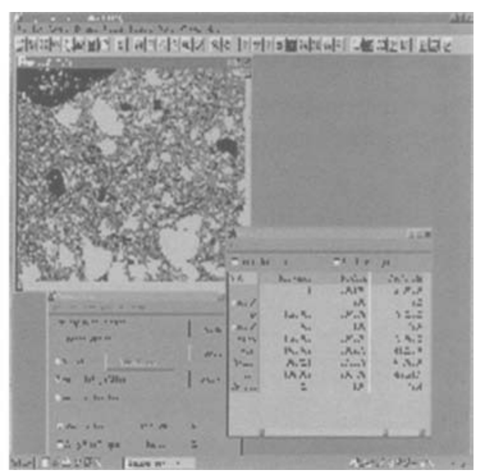
A variety of statistics can be calculated. One example would be to do a histogram of the distribution of grain lengths. Or, the data can be exported to a statistical package to compare the characteristics of two or more ceramic groups.

For comparison, Figure 15a shows another ceramic thin section, in plane polarized light. The hematite-rich clay has a sand temper that appears different from the previous one, more angular in shape and with more variation in size. These characteristics can be much more quickly and accurately measured with digital image analysis. Here again the counted sand grains are the bright objects within the darker clay matrix.

We can choose any number of measurements that might be significant in distinguishing between technological choices and/or between geological sources of the sand. In Figure 15b, for example, we are looking at the range and average degree of roundness, range and average lengths, and overall percent area covered by the sand grains. We might want to eliminate some grains from the measurements (the smaller ones, for example), or measure them separately if we think they may be characteristics of a coarse clay rather than being part of the temper additive.



15a. A ceramic thin section (x20) in plane polarized light. The light areas are angular sand grains within the clay matrix.



15b: The sand grains are highlighted by Image-Pro Plus for counting and measurement for a variety of statistics.

Finally, one characteristic of sand tempers that often reflects a geological source is the degree of rounding of quartz grains, an indication of how much a sediment was transported and worn down before deposition. In the past, the most common method of assessing this was visual estimation against reference photographs to identify grains that are rounded, subrounded, subangular, or angular. It is often difficult to make decisions between these categories, and because there is usually some variation, many grains must be included in an assessment. In the previous examples, the roundness of all grains counted was measured. If we want to focus on individual grains, we can trace around the edges of a grain, and calculate its roundness; in Figure 16 it is 2.16.

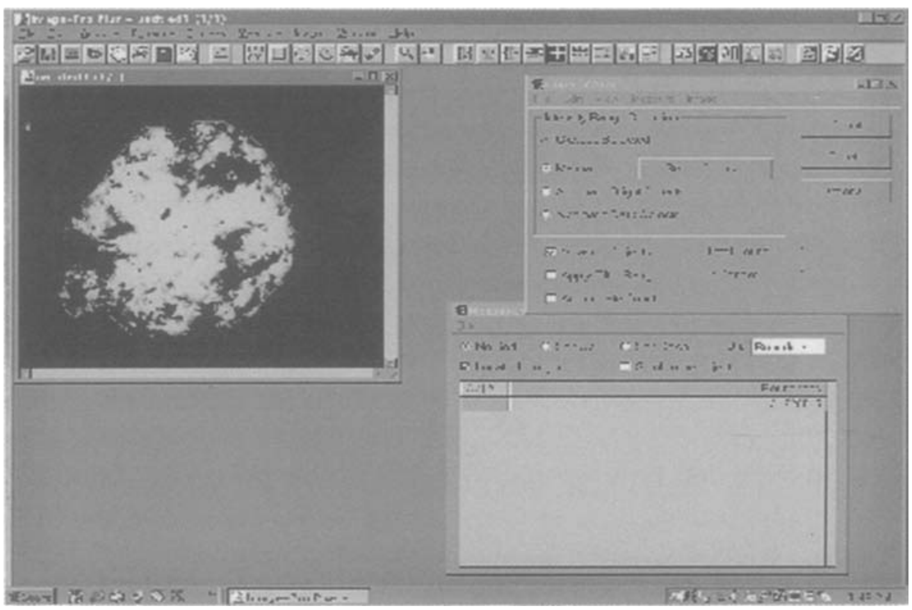


Figure 16. The roundness of an individual quartz grain within a ceramic sand component is calculated by tracing around the grain borders and selecting a roundness measure .

In Figure 17 we see a more angular grain, measured at 1.58. There are many, many more ways in which digital image analysis can aid in the characterization and study of objects and architectural materials. The existence of extensive materials analysis packages, eliminating the need for most in-house programming, makes this work practical and widely available. However, the analysis is by no means automatic, and still requires careful examination of each image and the selection of appropriate choices at each step of analysis.

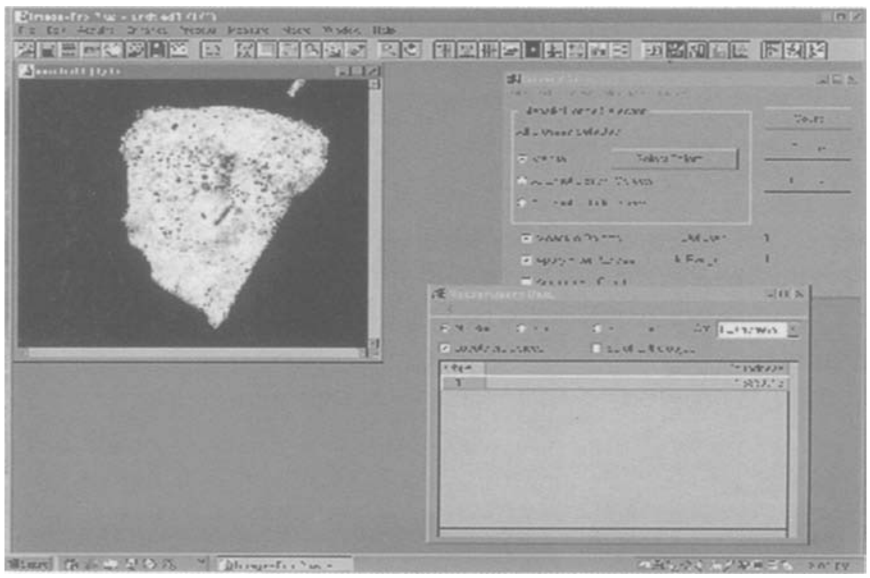


Figure 17. The roundness of this more angular grain (1.58) is found to vary greatly from that of the rounder grain (2.16) of Figure 16.

Note

Apologies for the low quality of many of the images used here. They were captured from screen shots and, unfortunately, the resolution is very low and could not be improved. Those interested in viewing the digital images should contact the author.

Acknowledgements

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Materials and Supplies

Image-Pro Plus, Media Cybernetics, www.mediacy.com

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