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SHELL

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CONSERVATION OF ARCHAEOLOGICAL SHELL OBJECTS

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NOTE: This *Conservation Note* is a revised and updated version of an article that was originally published in *The Bulletin of the Texas Archeological Society, Volume 58 (1987), p. 267-274*. The primary research for that article was conducted at the Materials Conservation Laboratory of the Texas Memorial Museum when the author was Associate Conservator of Objects at that facility. This article is reprinted here with permission from the Texas Memorial Museum, November 2003.

Introduction

Mollusc shell, when found in large concentrations such as those that occur in littoral shell middens, may be in excellent condition (Aten 1981:179; Meighan 1970:415; Sparks 1970:395-396). On the other hand, individual specimens that have been deposited in organically rich acidic soils in terrestrial sites may be weak and friable. A survey of archaeological field manuals revealed a lack of current conservation information on how to deal with these problems. Traditional field techniques often consist of dousing the finds with a proprietary formulation such as Elmer's Glue-All, not a conservation quality treatment material.

Figure 1. A shell midden deposit

The goal of this note is not to promulgate a panacea for all problems concerning shell specimens and artifacts. A written article can never substitute for the advice of an experienced professional archaeological conservator. You are encouraged to seek advice from such a professional *prior* to your field project, if your preliminary research and testing indicates that you might encounter problematic specimens. This contact will allow you to have the proper materials, equipment, and budget to deal with the objects in a responsible, professional manner. The American Institute for the Conservation of Historic and Artistic Works (AIC), based in Washington, DC, has a computerized conservator referral system. The listings are organized by geographic area and conservation specialty. The AIC does not check the credentials of anyone listed on the system, nor does it endorse any individual. It is up to the person or institution using the referrals to check references and portfolios. The system can be accessed by calling the AIC office at (202) 452-9545.

The proper conservation of any materials requires an understanding of the physical and chemical nature of that material.

The Properties of Shell and Taphonomy

Shells, as denoted in this publication, are the calcareous outer protective covering of invertebrate animals belonging to the phylum Mollusca. This phylum is divided into six classes: the two most important in archaeology are Gastropods, (snails) and Bivalvia (Pelecypoda, which includes clams, oysters, and mussels).

The shell itself consists of a matrix of calcium carbonate covered with a noncalcareous membrane called the periostracum, which is analogous to the periosteum on the outer surfaces of bones (Morris 1973:xviii). The proteinaceous component of shell is called conchiolin, which is the molluscan equivalent of collagen (Cronyn 1990:275). As the periostracum dries and flakes from the shell, it breaks the delicate growing distal edge of the valve (Aten 1981:186-187; Child and Bulter 1996:8-10). The shells of bivalves are excreted by tissue layers called the mantle, which cover the visceral mass (Weisz 1963:274). The shells of most bivalves are laid down in visible layers that are useful in seasonality studies, since the thickness and spacing of the layers correlate with the seasonal growth of the animal.

The primary parameters in the preservation of shell remains in the ground are:
—The pH level of the soil matrix
—The amount of shell in the deposit
—Aeration of the soil matrix

Secondary factors affecting preservation are:
—Human and animal disturbances
—Erosion

These factors allow chemical weathering and leaching to occur. For example, burning or calcinations of shell during food or artifact processing prior to discard leads to poor preservation. The habitat of the mollusk may also be important to preservation after death. The shells of some terrestrial gastropods that live on calcium-depleted soils may be thin and easily broken, and pelecypods that live in brackish or marine environments rich in calcium ions will be very well preserved. Although there are technical

distinctions among different types of shell midden deposits, the term is used here to refer to deposits consisting of almost entirely of shell remains (Meighan 1970:415). Water percolating downward through such a concentration shell may become charged with carbonic acid, causing a leaching and redeposit effect on the shells, serving to encrust or even cement some of them together with a caliche coating (Sparks 1970:395). The pH levels of shell middens that are deposited in initially acidic soils such as sandy loams can be raised to alkaline ranges that encourage the preservation of bone and other organic materials such as wood, cordage and seeds, especially if the site is wet or waterlogged.

Archaeological Importance of Shell Remains

Figure 1. A shell midden deposit

Shell has been used as a material for ornaments in the New World at least since the Archaic stage, perhaps reaching an artistic apex during the Mississippian period in Midwestern and Southeastern North America, therefore, the need for preserving shell artifacts is obvious. Shell refuse, on the other hand, can provide invaluable information about the economy of the site occupants, population, climate and habitat, radiocarbon age, and as determined from the season of death of the mollusks, the seasonality of the site's occupation (Aten 1981:179; Shackelton 1970:407).

In order to determine the seasonality from bivalve remains, a sample of at least 50 to 100 fairly complete specimens is needed. Aten (1981) describes in detail the morphological approach to the determination of seasonality in the Gulf Coast brackish water species *Rangia cuneata* (Gray). This approach requires that the outer edges of the bivalve be as well preserved as possible to allow measurement of the most recent growth rings. The exterior surface of the valve should also be stable, since powdering and flaking will obscure the earlier growth rings, making accurate measurement difficult.

Historical Field Treatments

The few manuals that deal with archaeological field conservation pay little or no attention to the problems attendant on the excavation of shell. With a few exceptions, most of these manuals are ten to over twenty years old, many of them are still used as the basic texts for student archaeologists when learning about conservation methods. Because of this fact, some of the statements found within them bear analysis. It is hoped that by pointing out the technical problems with some of the commonly prescribed methods, damage to collections will be avoided.

Dowman (1970), in her book which served as the main work devoted entirely to archaeological field conservation for almost twenty years, does not mention shell at all. Cronyn (1990) has a passing reference to shell in the section on organic materials. Joukowsky (1980:258) discusses the treatment of shell together with bone and ivory. For dry shell requiring *in situ* stabilization, she advocates the use of polyvinyl (PVAc) resin in acetone.

Lamb and Newsom (1983:30) in a misguided and dangerous attempt to standardize archaeological field conservation, state that "…shell artifacts generally do not present a problem with preservation". In a later paragraph, they contradict themselves by saying that in archaeological deposits, shell can become very fragile and they advocate the use of ethulose and PEG (polyethylene glycol; Carbowax). Conceding that these materials may not provide adequate consolidation, they describe the use of cellulose (sic) in either ethanol or acetone. They advocate Duco cement for use on shell in a "2% solution in alcohol". Duco is composed of cellulose nitrate and is soluble only in ether-alcohol mixtures and acetone. It is an unstable and unsuitable adhesive resin formulation. It is yellow to amber in color when first applied and becomes darker with ageing. Cross linking of the resin molecules occurs, making it brittle when used as an adhesive and difficult to remove with solvents when used as a consolidant (Selwitz 1988:47; Shelton and Johnson 1995:65). **It is very strongly advocated here that cellulose nitrate, in any formulation, never be used on any shell artifactual material.** Table 1 lists the polymer formulations mentioned in the text. The data is adapted from Elder et al (1997) and the author's experience.

Sease (1992) states that shell usually is found in good condition, but that if it is extremely friable, it can be consolidated by brushing on a 2 percent solution of acrylic resin (Acryloid B-72) in acetone or toluene. If the specimen is damp, Sease states that a PVAc emulsion can be used. However, if used as consolidants the PVAc solutions are insoluble once they dry completely, may be unstable and acidic (pH less than 7), and can attract moisture to joins if used as an adhesive. It is strongly suggested here that PVA c emulsions should not be used on shell artifacts.

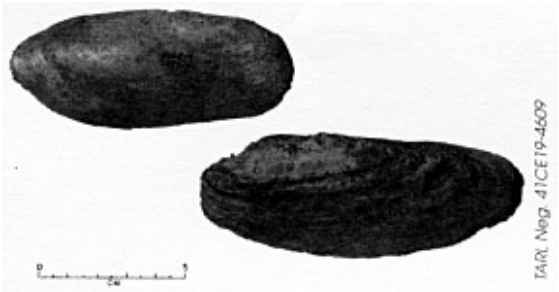

Figure 3. Drilled shell artifacts

Hester, et al (1997:150), recommend a 3-5% solution of Acryloid F-72 in toluene or acetone for consolidating flaking shells. They also mention the use of acrylic emulsions as an alternative to the PVAc emulsions recommended by Sease. In the earlier, 6th edition of the Field Methods in Archaeology, outdated references were used, describing the use of celluloid (nitrocellulose, cellulose

nitrate) on dry shells and gelatin/formaldehyde for damp shells. The latter treatment formulation is also unstable and harmful to the specimens, since formaldehyde will form formates with the calcium in the shell over time (Tennent and Baird 1985:77); Grzywacz and Tennant 1996:21-27).

Materials Used for the Preservation Shell

As can be seen from the literature sources described above, there is no consensus as to the best treatment for shell, whether it is wet or dry. In choosing any treatment materials and method, many factors are taken into account. When choosing a consolidant for weak and friable shell, the following characteristics of a resin are important. For further information on the nature of adhesives and consolidants see *Science for Conservators, Volume 3* (1994) and Johnson (1994).

—The materials must be chemically compatible with the artifact material. For shells, this means neutral or slightly alkaline (pH >7; <10).

—The materials must be stable over time. Shrinkage, embrittlement, and yellowing are unacceptable conditions.

—Reversibility of a consolidant is generally not possible, but at least the surface can be cleaned off with a solvent if retreatment due to physical damage is necessary.

—Low toxicity to the operator is essential. Chlorinated and aromatic solvents should be avoided, as well as solvents with very slow evaporation rates.

Treatment Recommendations: Field

Based on experimentation and experience, the following materials and techniques are recommended for shell materials. The field conservation techniques described below require time and patience. These techniques, in order to be of the maximum effectiveness, cannot be rushed. The Principal Investigator of the excavation must be aware of these issues and understand the basis of conservation methodology.

In the field, when conditions are dry, Acryloid B-72 diluted with acetone to 3%-5% gm/ml should be used. The PVAc resins are acceptable, but will soften in storage conditions above 80-85°F.

1) Remove as much of the surface dirt as is possible from the individual objects on the exterior of the block. Use soft brushes, bamboo skewers and dental tools. This will allow for better penetration of the consolidant and for easier cleaning in the lab.
2) It is best to apply a light spray of pure solvent onto the objects being treated before the consolidant is applied. This helps to drive off residual moisture and to introduce the solvent onto the materials, aiding penetration of the consolidant.
3) In a midden site, the individual pelecypod valves may be tightly packed together. For optimum recovery, excavate a pedestal, consolidate the shells with the surrounding matrix, and remove the sample in a block, either with or without jacketing. This is the standard method of removing fragile bone and other objects and has been described in detail elsewhere (Rixon 1976; Storch1983, Sease 1992). Use thin polyethylene sheeting as a barrier between the specimens and the plaster bandages. Do not cover the objects with paper of any kind, as it can stick to the surfaces and pull off materials when removed. Mark the plaster bandage jacket after it sets up completely with whatever information is necessary to inform someone on how to remove the jacket safely. It also must be marked with lot/catalog/accession and what other numbers are needed to maintain provenience.

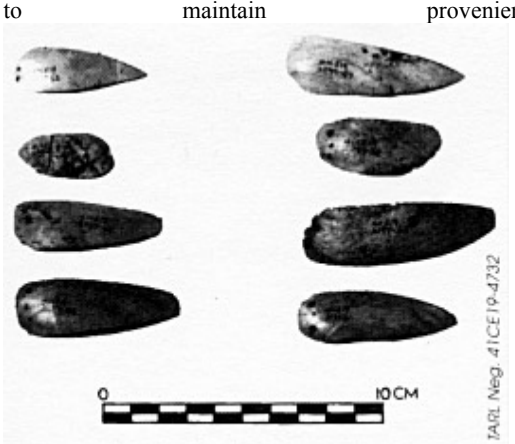

Figure 4. Shell artifacts. Note the deteriorated surface on the lower shells.

4) If pedastalling cannot be done due to, but not limited to, the following examples, an extensive deposit that would be impossible to remove in a block; a very hard, cementitious deposit; or simply the lack of time due to excavation and project logistics, then the deposit must be sampled. The sampled area can be cleaned and consolidated *in situ* as described above if time allows and it is necessary for removal to avoid complete loss.
5) Once removed from the excavation unit, the sample objects can be cleaned on the remaining surfaces and consolidated prior to packing.
6) When wet or damp shell is encountered, an aqueous-based consolidant is required because it would be impossible to allow the materials to dry enough to use a solvent/solute system. Use of a solvented resin on materials that is too damp will result in formation of a white skin on the surface and lack of penetration. The recommended water-based consolidant in Rhoplex AC-33 acrylic emulsion or one of the acrylic dispersions (see Table 1). It can be used as supplied, which is 45% solids, or diluted with distilled or deionized water. It is the most stable of the emulsion formulations and is of neutral pH. The sheen can be toned down by swabbing with acetone once the material is stable and dry. Koob describes the use of this consolidant on archaeological bone (1984). The same pedastalling method can be used with the emulsion as the one described for the solvented acrylic system.

Treatment Recommendations: Laboratory

1) Once the specimens have been returned to the laboratory, they should be carefully removed from the jackets and placed in an environmentally stable area (without major fluctuations in temperature and RH, i.e. within +/-5°F/day). Do not, leave the specimens in their jackets indefinitely as mold can form if the specimens

were damp before jacketing. This can cause staining and deterioration of the shells.

2) Cleaning of consolidated specimens can be done by dissolving the adhered matrix with the correct solvent. Once they are cleaned, the actual surfaces of the specimens can be reconsolidated by dripping, brushing or spraying, depending on the nature of the surfaces and the desired appearance.
3) Broken objects can be mended with a 1:1 solution of B-72 in acetone, after excess moisture has evaporated. The adhesive can be applied to each side of the mend with a brush. The excess can be removed with acetone on swabs after the mend is stable. Light pressure clamping with rubber bands and a sand box can be used. Avoid masking tape and other pressure sensitive tapes to hold fragments together during mending as the tapes and the adhesive residues can be very difficult to remove completely from porous shell. Objects that require more than simple cleaning and mending should be treated by a qualified archaeological objects conservator.

Documentation is extremely important to the conservation process, particularly in the field prior to the stabilization process. Detailed close-up should be taken, with scales and proper labeling used. During treatment photos can be taken in the lab prior to and after the jackets are removed, then as necessary during the cleaning and final consolidation treatments. After treatment shots, both detail and overall, must be taken. Both color slides and black and white prints are useful.

Table 1. Identities of Commonly used Polymer Resins in Archaeological Conservation
(Adapted from Elder, et. al, 1997)

Trade Names	Chemical Family	Chemical Composition	Historic Uses and Comments
Acryloid (Paraloid) B-72	Acrylic Polymers	Ethlmethacrylate (EMA)-methlmethacrylate (MMA) copolymer	Adhesive and consolidant commonly used in conservation; excellent stability and reversibility
Rhoplex WS 24	Acrylic Polymer	EMA and MMA, ethylmethacrylate (EA)	Adhesive and consolidant for damp and wet bones
Duco Cement, 3M Household Glue, Ambroid, Glyptal, HMG	Cellulose Nitrate	Cellulose polynitrate ester (CN); with dibutyl phthalate, camphor or triphenyl phosphate plasticzers	Adhesive, consolidant and coating for a plethora of archaeological objects and materials; poor stability; yellows and shrinks; very deletrious in the long term to objects
"Super Glues"; PaleoBond, Zap	Cyanocrylates (Poly(alkyl 2-cyanocraylate))	Ethyl cyanoacrylate and poly(methyl methacrylate)	Adhesive and consolidant for geological and paleontological materials; not for use on alkaline materials (e.g. shell); may have brittle failure; degradation.
PEG, Carbowax	Poly(ethylene glycol)	Variable molecular weight condensation long chain polymers of ethylene glycol; viscous liquids to waxy solids	Consolidant for damp and waterlogged wood, leather and bone.
Mowilith, Vinylite, AYAA, AYAF, AYAC, AYAT	Poly(vinyl acetate) (PVAc) resin	Vinyl acetate homopolymer	Adhesive and consolidant for a variety of archaeological materials; bone, ceramics; easily reversible and stable over the long term

Table 2. Ratings for a Shell Collection Condition Assessment Survey
(Adapted from Storch 1987:270)

Rating	Surface	Pitting	Striations	Layer/Edges	Stability
Excellent (1)	Not powdery	None	All visible	Complete	Stable wet and dry
Good (2)	Exterior surfaces slightly powdery	Some	Most are visible	Most outer edges are extant	Stable wet and dry
Fair (3)	Exterior surfaces are powdery	Yes	Mostly obliterated on the exterior	—	Unstable when dry; flakes or crumbles to the touch
Poor (4)	Flaking, crumbling, soft	Heavy on exterior surface	—	—	Minimal; soft, unstable when wet or dry

Curatorial Considerations for Shell Artifacts in Collections

Prior to doing any actual treatment, an essential component of the preservation orientation of conservation is a condition survey of the objects in the collection. If the collection is of a manageable size, it is advisable to survey and assess each object individually. If it is large and the information to be obtained and preserved justifies treatment, contact a qualified professional

archaeological conservator for advice on survey sampling and mass treatment methods.

The above table is offered as a model for a condition assessment survey instrument. The ratings are qualitative, however, if survey forms are properly designed and used, the results of a survey can be qualified and used to estimate required time, cost and supplies needed for a well organized conservation treatment project.

The rating descriptions were based on the features that are needed for species identification and seasonality studies. If you are assessing a collection of decorated shell objects, then obviously you will have to adapt the survey criteria to describe and assess the condition and "readability" of the decorative surfaces.

Once the condition has been assessed, the data can be used to decide upon a treatment option and to design a course of treatment.

Laboratory treatments are done in controlled environmental conditions, relative to the field. Usually, there is not the degree of time constraint in the lab as there is in the field. The limits of the conservation materials do not have to be pushed, as sometimes must be done during an excavation.

Often, a block must be removed before it can dry completely due to changing weather conditions or to simply keep on the overall excavation schedule in order to meet the season's predetermined goals of reaching a specific level or feature. Lab treatment can be much more detailed than field treatments, concentrating on saving smaller areas of the objects. Mounts and supports for blocks and individual objects can be made in the lab, and preparation of the objects for exhibit purposes can be done.

Summary

It is difficult to describe every possible object, condition, or problem that might be encountered in the field and lab, but it is hoped that this note can help to solve some of the problems posed by fragile shell materials. It is essential to know what objects to expect to excavate at a site, and to properly plan for their stabilization and later conservation treatment. It is no longer acceptable professional archaeological practice to ignore conservation concerns until the collection is literally falling apart and can no longer impart any useful scientific information. The goal of including conservation in the excavation research design is to preserve as much of the information inherent in the objects as is possible. This article should serve as an introduction as to what is involved to achieve that goal with shell materials.

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