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FIELD AND LABORATORY METHODS FOR HANDLING OSSEOUS MATERIALS

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During an archaeological excavation, situations often arise that require some knowledge of conservation methods and materials to ensure safe removal of fragile objects from the ground. *Osseous materials* refers to non-fossilized bone tissue, teeth, ivory, antler, and horn from either animals or humans. This article covers the basic nature of osseous materials, their deterioration, and proper treatment and packing methods. The information contained herein is not a substitute for the direct advice and aid of a trained archaeological conservator; it should be used only as a guide in making decisions.

The Nature of Osseous Materials

Osseous materials were once living tissues consisting of both inorganic and organic components. The inorganic component includes calcium carbonate and calcium phosphate organized into a crystalline solid called *hydroxyapatite*. The organic component is a coiled protein fiber, known as collagen. Horns and hooves have *keratin* as the protein component, which is chemically similar to collagen. Teeth and ivory have an inner core of dentine and an outer layer of enamel, both of which are composed of inorganic and organic substances (Plenderleith and Werner, 1971:148-161; Von Endt, 1984:31-36).

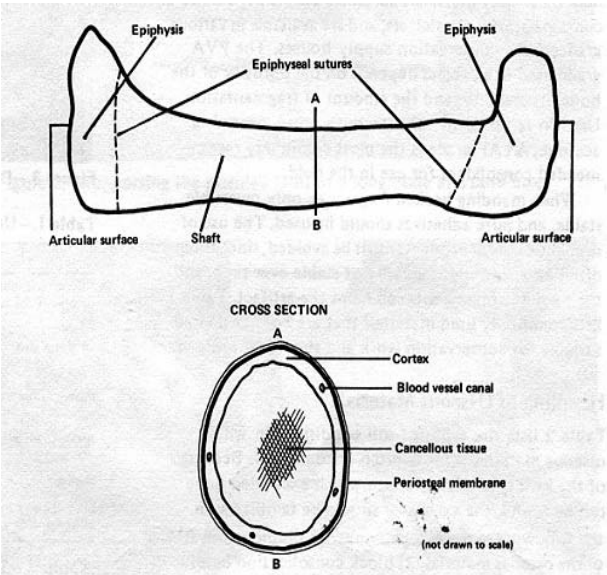

Figure 1.—Schematic diagram and cross section of mammal bone.

Bones, also referred to as skeletal elements, are basically similar in structure among most vertebrates (Fig.1). The inner network of

osseous material, also called *cancellous tissue* or spongy bone, allows for the support of marrow-forming cells and blood vessels. Surrounding the cancellous tissue is the outer compact *cortical bone*, which is composed mostly of hydroxyapatite. Narrow canals and openings throughout the cortical layer allow for the passage of blood vessels. During the life of the animal, the cortical bone is covered by a surface membrane called the *periosteum* that decays after burial and is rarely preserved in archaeological material (Von Endt, 1984).

Deterioration of Osseous Material

Osseous materials are destroyed by a combination of physical and chemical factors which often work simultaneously and synergistically.

Physical agents- which include soil crushing, soil movement, gnawing by rodents and other animals, earthworms and other burrowing animals, and freezing and thawing- break down bone by mechanical action. The cortical bone is fractured, allowing chemical factors to deteriorate the inner cortex and cancellous tissue (Hill, 1980).

The organic components are initially broken down by acids and enzymes secreted by decay fungi and bacteria. Other factors, such as humidity and soil pH, also contribute to organic decay (Buikstra and Gordon, 1981). The inorganic component is broken down by hydrolytic reactions with carbonic acid from ground water. This reaction is dependent upon soil composition and pH (White and Hannus, 1983:316-322). High soil moisture content, although helpful in certain special situations, is generally harmful both physically and chemically. Osseous materials that are constantly wet eventually crumbles (Brothwell, 1981:7-8).

Conservation Materials

Opinion varies in the archaeological field regarding the proper treatment materials to use on osseous materials. Some materials come from parallel fields, such as geology and palaeontology. For a more comprehensive list and explanation of current materials applied in archaeological, geological, and palaeontological conservation, see Elder, et al (1997).

Polyvinyl acetate resins (PVAc) have been found to be generally applicable in most situations with osseous materials. They dry clear, are fairly stable over time, do not contain harmful plasticizers, and are available in various grades from conservation supply house. The PVAc grade that is used in a project depends on the porosity of the bone, its stability, and the amount of fragmentations. Used in ten percent solution with ethyl alcohol or acetone, AYAF grade is the most commonly recommended consolidant for use in the field. The disadvantage of the PVAc's is that they can cold-flow due to relatively low glass transition temperatures (T_g) under warm conditions, such as those found in uncontrolled repository buildings. This means that the mends can shift, causing misalignment of the mends and inaccurate measurements.

A resin that has been found by extensive testing to be the most stable synthetic polymer available is Paraloid B-72 (Rohm and Haas Corp.), an ethyl methacrylate-methyl methacrylate copolymer. It does not yellow and cross-link and is estimated to retain its chemical and physical stability for over 100 years. It is widely used by archaeological conservators to stabilize osseous materials, molluscan materials, ceramics, and metals. It has a higher glass transition temperature than the PVAc's, which makes it less prone to cold-flow. It is soluble in acetone. A 5% weight/volume solution in acetone is commonly used for consolidation, and a 1:1 acetone solution for mending.

Stable acrylic resins are also supplied as emulsions and dispersions, such as Acrysol WS-24 (Rohm

and Haas), which are useful when bone is damp or wet and a solvent based resin solution cannot be used. Once the emulsions or dispersions dry, however, the resin must be removed with a solvent such as acetone. The reversibility of resins that have been applied as consolidants is negligible. When mending broken fragments, only reversible, stable, and pure adhesives should be used. The use of over the counter products must be avoided, since these often have formulae that are not stable over time, and their volatile ingredients can harm the artifact. All cellulose nitrate-based adhesives should be avoided since they are externally plasticized, turn yellow due to oxidation, cross-link very quickly, causing damage to objects when the joins fail due to brittleness (Selwitz, 1988). White glues, shellac, epoxies, spray acrylics, beeswax, and other proprietary compounds must also be avoided. Check with an archaeological conservator if you are faced with removing these problem materials from previously mended objects.

Handling Osseous Materials: Field Methods

Table 2 lists the types of soil conditions in which osseous material is most often encountered. Due to the variety of conditions in which excavated bone can be found, the excavator should be familiar with the following removal techniques:

1) simple removal of the osseous material;
2) block consolidation before removal;
3) plaster block consolidation.

Table 2: The general effect of soil conditions on osseous materials and handling recommendations

Soil Conditions	Condition of Materials	Handling Recommendations	Recommended Resin
Dry sand, clay, or caliche	Dry: fragile and friable	*In situ* consolidation, Combined with plaster block removal	B-72 5% dilution in acetone or toluene
Dry sand, clay, or caliche	Dry: stable	Removal, dry cleaning	B-72 5% dilution in acetone or toluene, if needed
Moist to wet soil matrix- all types	Wet: fragile and friable	Controlled drying during excavation; consolidation possibly combine with plaster block removal	WS-24 or equivalent 25% dilution as supplied in distilled water to consolidate
Water-logged terrestrial sites	Completely saturated: fragile and friable	Plaster block removal: keep sealed in matrix and keep wet until the specimen can be treated in a conservation lab	Consult conservator

Simple Removal:

When excavating osseous materials in stable condition, as much of the matrix as possible should be cleared away from all sides of the artifact in order to assess its physical condition. It is generally safer to excavate the artifact completely with dental picks and other small hand tools, but if time does not permit use of this relatively slow technique, one may excavate from 1 to 1.5 cm below the object and remove the soil with it. Unless the object is very dense, such as bison bone, it should be wrapped in tissue or paper towels and placed inside a foil package. If at all possible, osseous materials should be packaged separately from other artifacts and labeled as fragile. Optimally, all the bones from a site should be boxed together at the end of the season.

Block Consolidation:

Wet, fragile, and friable materials require the second, or block consolidation technique of removal. After delineating the margins of the artifact and assessing the extent of its deterioration, the artifact and surrounding soil should have time to dry- usually 3 to 6 hours, depending upon weather conditions. If the soil and material are initially dry, *in situ* consolidation can proceed immediately. The following steps outline the basic procedures (Also see Converse 1984:23-26).

1) The artifact and approximately 2 cm of soil around it are sprayed with acetone. This will help moisture to evaporate and allow the acrylic resin to penetrate the artifact more completely.
2) The solvent spray should be reapplied at least once, and then the consolidant solution may be sprayed both on the artifact and on the soil margin. Apply two light coats and allow to dry for ½ to 1 hour. Too thick an application will prevent adequate penetration and thus fail to strengthen the artifact sufficiently.
3) The application is repeated until it is judged that the artifact has gained enough strength to withstand the pressure of excavation and removal. To determine the strength of the artifact, a slight pressure may be gently applied to its surface with a blunt tool, such as a bamboo pick. If the consolidation has been successful, there should be no loss of bone or soil from this action.
4) As with the excavation of stable material, it is necessary to excavate to a depth of 1 to 1.5 cm below the artifact and 2 cm around its periphery and remove the artifact and the matrix. Some of the matrix will fall off, but the consolidant should have penetrated it sufficiently so that it forms a support "base" for the artifact.
5) The block is wrapped as described above for stable material and the bag or package clearly labeled with the name of the consolidant used and any other pertinent treatment information. This information will be invaluable to the technician who has to deal with the cleaning and storage of objects and should also be entered into the field notes. Figure 2 illustrates a properly consolidated and labeled block of bone awls.

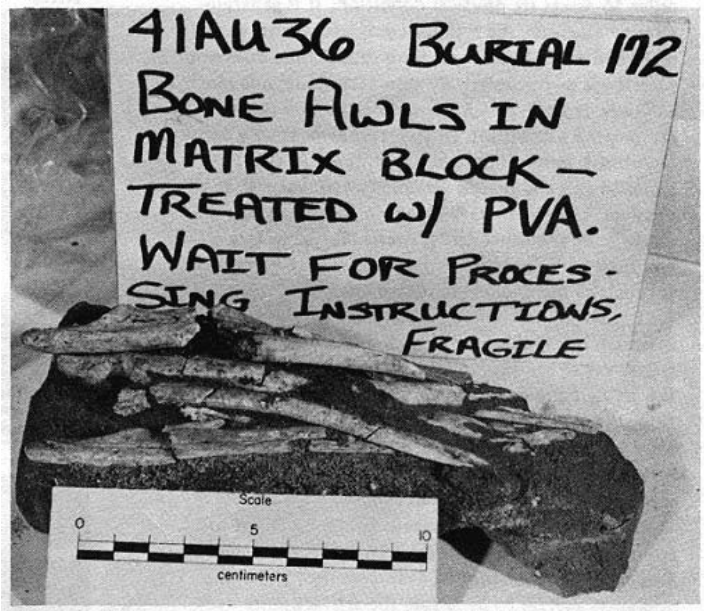

Figure 2.—Bone awls made from small mammal ulnae removed to the laboratory in a consolidated block.

Plaster Block Consolidation:

When artifacts must be removed together in a block, the technique described under block consolidation should be employed. Plaster bandages are then applied around the bock before removal. It is suggested that a plastic such as thin polyethylene or polyvinylidene chloride ("Saran" or freezer-type wrapping) be used as barrier between the artifact and the plaster bandages rather than wet tissue paper or toweling, both of which can become tightly bonded to the surface of the artifact and cause removal problems. Furthermore, moisture held by the paper can retard the setting of the innermost bandages. Dry sand can be used as a barrier if the top of the block is flat enough to allow for the build-up of a 1-2 cm layer. Bandages pretreated with plaster that only require the application of water have also been used successfully in field situations. For thorough discussion of the plaster- bandaging technique in the field, see Hester, et al (1997) and Rixon (1976:46-50). It is suggested that the artifacts be removed from the plaster block as soon as possible after returning to the laboratory, since it is difficult to predict the long-term effects of the environment created inside the block.

Cleaning and Mending

1) Very little water should be used in cleaning untreated materials. Never soak osseous material in water and never use a scrub brush or toothbrush on them. This may leave marks that could be misinterpreted during later analysis.
2) Moderately stiff brushes, such as artist's glue brushes and wooden or dental picks, are sufficient to remove dried soil. Soil lodged in the cancellous network of the bone need not be removed. The use of chemical water additives such as scale removers and water softeners must be avoided since these products contain phosphoric and hydroxyacetic acids and sequestering agents that are highly destructive to osseous materials. If it is necessary to remove caliche deposits (precipitated

calcium carbonate crusts) from the artifacts, an archaeological conservator or palaeontologist, who has had experience with the chemical cleaning of osseous fossil and sub-fossil materials, should be consulted.

3) Cleanly broken fragments may be mended if it is deemed necessary for the purpose of measurement and analysis. Paraloid B-72 is used in a 1:1 solution with acetone. A more dilute solution can first be applied to slightly friable edges to stabilize them. The artifact should be allowed to dry prior to mending. A small amount of the adhesive is then applied to the ends, pushing them together as tightly as possible without causing further breakage. The artifact is supported in a box with clean sand until the adhesive has set firmly, usually 12 to 24 hours.
4) Excess adhesive that has oozed from the joint can be removed with acetone on a cotton swab. The acetone should not be allowed to penetrate the joint and thus weaken it.
5) Paraloid B-72 has a glass transition temperature of 40°C (104°F), above which point it may soften. Do not expose mended materials to hot photographic lights. Use ambient light or flash photography when documenting specimens.

Packing and Housing

The final stage in dealing with stabilized osseous materials is to pack and house them in such a manner as to minimize the possibility of further deterioration. One should refer to the Minnesota Historical Society and Minnesota State Archaeologist curatorial requirements if the material are going to the Society under a repository agreement.

1) It is recommended that fragile bones such as human long bones be individually wrapped in cushioned polyethylene sheeting know as "bubble pack". Be sure that bubble pack is made of polyethylene and not a different, damaging plastic such as polyvinylchloride. A bubble diameter of 1 cm allows enough flexibility to wrap the artifact sufficiently. It should not be wrapped so tightly that mechanical stresses are introduced. The bubbles are on the outside of the wrapping.
2) The packing box, which should be of lignin-free board, should also be lined with one layer of the bubble pack sheeting.

The environmental conditions under which archaeological materials are stored determine the long-term stability of those materials. The important parameters in the preservation of osseous materials are temperature and relative humidity. The recommended ranges are as follows:

1) Temperature: 60-70°F +/-5°F daily fluctuation
2) Relative Humidity (RH): 40%-50%+/-5% daily fluctuation

These are fairly wide ranges, but it is understood that many institutions have limits on the types of air and environmental systems that they can afford. Even at the upper limits of temperature and RH, the risk of further deterioration in the materials will be markedly reduced if the daily fluctuations are kept to a minimum. Proper wrapping and packaging of artifacts can form a buffer against environmental fluctuations by decreasing the amount of ambient atmosphere that reaches the artifact.

There are, of course, many other environmental considerations in regard to housing, such as pest, microorganism, and fire control that are beyond the scope of this paper. Also, it is impossible to describe all possible field conditions and treatment problems in a paper of this size. However, it is hoped that this will serve as a helpful introductory reference to the processes which affect

archaeological materials and as a guide to making informed decisions in the field and laboratory.

Suppliers

Tools, Resins, Solvents
Conservator's Emporium
100 Standing Rock Circle
Reno, NV 89511
(702) 852-0404

Conservation Support Systems
924 West Pendregosa Street
Santa Barbara, CA 93101
(800) 482-6299
http://www.silcom.com/~css/

Lignin-free boxes
University Products, Inc.
www.universityproducts.com

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