A Review of Vertebrate Fossil Support (and storage) Systems at the Yale Peabody Museum of Natural History

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Abstract

Proper storage of paleontological specimens is as important to their long-term usefulness as is good preparation. One aspect of proper storage is adequate support for fossil bones, which although they appear strong lack the internal strength of living bone. Fossil bone can and does break under its own weight without external support. This support can include specimens stored within specimen trays, as well as those large or fragile specimens that require more elaborate bedding jackets. For smaller specimens within trays support is often polyethylene foam cut to fit the bone. Bedding or storage jackets for large bones are generally plaster and fiberglass or resin and fiberglass with additional supports of either metal pipe or wood.

This presentation offers a review of current storage support methods, their advantages and disadvantages.

Why are we interested in storage?

> "In recent years conservators, curators and architects have become increasingly aware of the effects of the environment upon museum collections. We now make great efforts to control such known causes of deterioration as temperature, humidity, light, airborne contaminants, insects and handling. However, we often forget that all objects have weight; and it is this forgotten factor - the ever present effect of gravity - that is one of the prime causes of physical deterioration."
>
> P. Ward, Poor Support, the Forgotten Factor, Museum, 1982

Those of us who work in paleontology know that fossils are not as sturdy as they look. Although they appear strong, they lack the internal strength of living bone. Fossil bone can and does break under its own weight without external support. Fossils stored sitting on their teeth, rocking to and fro within drawers as they are opened or lying on hard shelving are often damaged just due to the storage conditions.

We have been involved with the conservation of the Yale Peabody Vertebrate Paleontology collections for several years now, on two National Science Foundation funded projects. Our first project was concerned with the conservation of the large dinosaur specimens collected in the late 1870's under O. C. Marsh. Our second NSF funded conservation project involved repairing, and conserving the specimens given by Princeton University to the Yale Peabody Museum in 1985.

At the time that we began the Princeton conservation project, the two collections were housed separately, but integration of the two collections was planned. In addition to rehousing the specimens, each element of each specimen was photographed and archivally labeled with the institutional prefix - either YPM or YPM-PU and the catalog number.

Both of these parts of the YPM collections were in need of improved storage methods. Described below are some improper storage methods, followed by some possibilities for improved storage solutions. This paper also shares some of the thinking behind the storage decisions that were made during these and ongoing YPM collections conservation projects.

Thinking about storage methods for all sizes of specimens

In working on specimen conservation projects, we are making storage decisions for all sizes of specimens, from the very tiniest mammal tooth to the largest dinosaur bones. Here they have been divided into rough groups, based on differing storage considerations. And it is worthwhile at this point to consider whether the method that has been used traditionally is really the best way, based on space and financial limitations, that we can find to house these specimens?

How do other institutions house fossils? Is there a literature that will help us in making the best decisions? Where do you find information on the types of storage methods available or preferred for these specimens? In preparing this paper the author looked in a number of places, including the Getty Institute - Art and Architecture Technical Abstracts, and the Journal for the American Institute for Conservation - JAIC online. The majority of the literature is in anthropological conservation, describing supports for archaeological or ethnographic artifacts. Support methods are occasionally mentioned for Recent osteological specimens. These may not be appropriate for specimens of the size and weight of fossils.

Very, very small - single mammal teeth, specimens too small to have the specimen number written on the specimen

Specimens this small have generally been stored either adhered to pins embedded in corks stuck into glass vials or within gel caps. Both of these methods have advantages and disadvantages. Very often the decision to use pins or not needs to be made by the person working with the specimens, based on their preferences and the needs of their research.

- **Specimens adhered to pins**
- **vs.**
- **Specimens without pins**

There is no specimen on this pin.

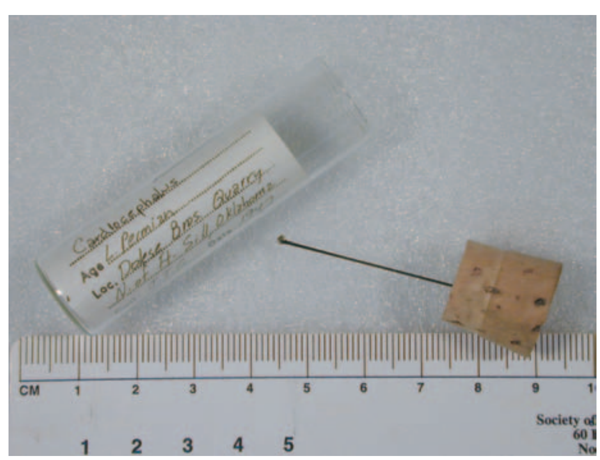
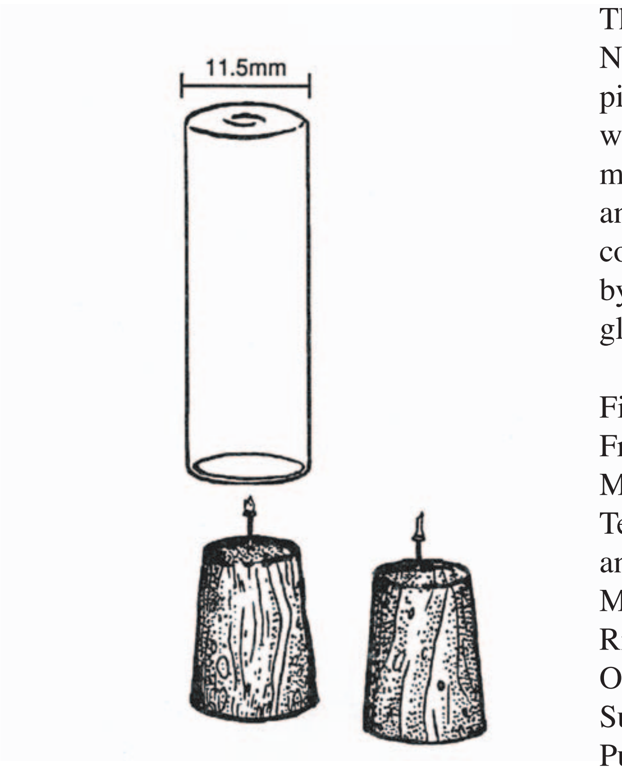


Figure 1

The specimen (or lack of specimen) shown in Figure 1 is an example of the pin method that has failed. Why is there no specimen attached to this pin? In the first place, the pin is too long. The longer the pin the more flexible it will be and the more likely the specimen is to fly off, never to be seen again. It can also very easily be knocked against the side of the vial upon removal from the tube, causing damage to the specimen. Two, as this was glued in the 1960's or 70's, the specimen was adhered with Duco Cement, notorious for its failure rate. Three, over time, cork, being an organic material, shrinks and can loosen from the tube.



This example, from a paper by Scott Madsen of Dinosaur National Monument in Utah, is a better example of a pinned specimen. Scott mentions adhering the specimen with a reversible glue such as PVA or Butvar, or microcrystalline wax. He also mentions the advantages and disadvantages of each adherent. Important considerations are that some information will be covered by the pin and that no matter how easily reversible the glue or wax, some residue will be left on the specimen.

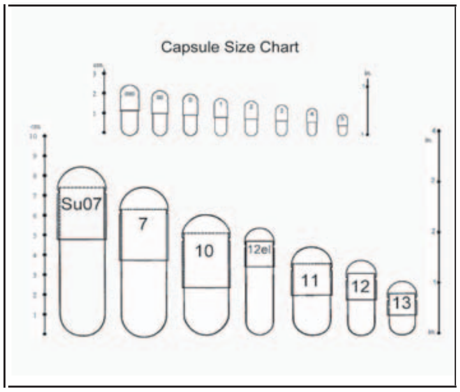
Figure 2
From: Some Techniques and Procedures for Microvertebrate Preparation. Scott K. Madsen, in Techniques for Recovery and Preparation of Microvertebrate Fossils. Richard Cifelli, editor. Oklahoma Geological Survey, Special Publication 96-4. 1996.

During the YPM Princeton Collection conservation project many of the specimens were removed from the pins. Where the specimens were left on pins, the pins were shortened and re-adhered with Paraloid B-72. When the specimens were removed from pins, the specimen was placed in a gelatin capsule, using polyethylene foam backer rod to gently hold the capsule in place.

The original plan called for making vial stoppers from plugs of polyethylene foam but we then learned that polyethylene foam loses its elasticity and so is not suitable. Therefore, where pins were considered necessary the plug is cork. As an alternative to cork, one could use either polyethylene or polypropylene stoppers, but these are harder to find in the appropriate sizes and more expensive.

Figure 3. Vial storage for a very small specimen. The specimen catalog number is written on the gelatin capsule.

Gelatin capsules are an inexpensive alternative to pinning small specimens. However, they are affected by moisture and become brittle over time. Gelatin capsules should be placed within another closed container to protect them. Polypropylene capsules exist, but are far more expensive. The catalog number, with the prefix-YPM or YPM-PU, is written on the capsule.



Figures 4 and 5. A standard capsule size chart, and size 00 gelatin capsules.

Small - small mammal or lizard jaws, small bones

Figure 6. A fragment of a small mammal jaw

Figure 7. The use of old random boxes should be avoided.

Figures 8 and 9. Open trays that are too shallow can cause specimen loss or mixing.

The trays seen in Figures 8 and 9 are not only old and of random sizes and shapes, but also very shallow. Material can easily spill from one to another and specimens become confused. It is a good practice to store very small specimens within closed containers

Figures 10 and 11. Very small specimens stored in cotton.

In general, no cotton or polyester fiberfill should ever be used to directly support fossils, particularly small fossils. It can all too easily snag on the rough edges of a small specimen and cause breakage when the specimen is removed from storage.

Also, if a specimen does break or suffer adhesive failure as see in Figure 12, the small pieceshave to be carefully searched for in the cotton. If either material is needed for support, a layer of Soft-structure Tyvek® styles 14M and 14MX (Dupont brand of flashspun high-density polyethylene fibers) or acid free tissue as a separating layer is all that is needed to protect the specimen from the fibers. Other materials that protect the specimen from fibers or, if the specimen is very fragile, from abrasion by the cut edges of polyethylene foam, are a thin layer of softer polyethylene foam or PTFE (polytetrafluoroethylene), the same material as plumber's Teflon tape, sold in 12" wide rolls.

Figure 12.
A small, broken specimen stored on cotton.
Tiny fragments can be lost in the cotton fibers.

Two factors are of primary interest when choosing synthetic materials.

(1) The stability of the plastic material itself must be considered. Will it degrade or change color? Most importantly, will it give off harmful chemical compounds such as acids or plasticizers as it ages? Additives used in the formulation of the end product can contribute significantly to the product.

(2) The physical properties of the plastic must be appropriate to the task. Many of the most common plastics have found their way into widespread use in museums - as storage containers, building materials and as artifacts. In determining the appropriate uses for these materials, it is helpful to have an understanding of their properties and where they are found, as well as a knowledge of the problems that have been observed in using them in proximity to museum objects (Williams 1997)

from: Pollutants in the Museum, Practical Strategies for Problem Solving in Design, Exhibition and Storage, Pamela B. Hatchfield

It is important to be aware of the materials that are used and their effect on the specimens.

Figure 13 is a common, small sized box used for small specimens made of polystyrene. Polystyrene is not a vapor barrier and is attacked by hydrocarbon solvents (i.e. acetone). There is some disagreement as to whether polystyrene is acidic. It does yellow and become more brittle over time.

More archivally acceptable options are Figure 14, polyethylene terephthalate boxes - PET, such as those created by the Canadian Museum of Nature. A number of people have explored these boxes and while they may be more archivally stable, they are certainly much less physically stable. They are too thin to hold heavy fossils safely, although they may be adequate for small specimens. The other boxes shown here in Figure 15 are from Metal-Edge and are made of 20 mil polyester. Both options are considerably more expensive than polystyrene.

Another possibility is polypropylene or polyethylene containers, such as commonly available food storage containers, for storage of loose matrix. Results of Oddy tests of containers made from these materials recommend leaving the containers open for up to 15 months to allow for off-gassing of manufacturing by-products.

Oddy tests for off-gassing of harmful volatiles measure the reactions of metal. The results may not be applicable to fossil material as more than a general caution. However, if a certain storage material reacts strongly with the three metals used in the tests, lead, copper, or silver, then one could probably assume that it is too acidic to be in contact with a fossil.

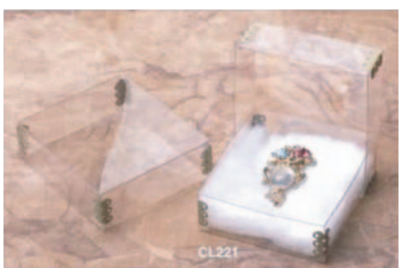


Figure 15. Polyester boxes

Figure 14. PET boxes


Figure 13. Polystyrene boxes

Figure 16

This is typical of current YPM storage for small specimens. It is a combination of already existing corked glass vials, with capsules inside them, and, for specimens with many small pieces, closed polystyrene boxes. For some specimens a closed box is preferable. Unless the specimen is small enough to fit inside of a gel cap, the tiny bone may be crashing into the hard side of the vial. It is possible to line the vials with thin foam, but the foam liner caneasily be dislodged. It is important to remember that our primary goal is to enable research and that these specimens are studied. Proper storage should not make it difficult for the researcher to access the specimens. These 2 dram shell vials had been extensively used throughout the YPM collections. By not changing the vials we avoided the cost of obtaining entirely new containers.

Medium - 3” - 10” in length

Figure 17

Figure 18

Unsupported bones, like those in Figure 17, roll every time the drawer is opened, crashing into each other. Pieces break off, and adhesives are stressed.

For mid-sized material it is simple to basically adapt conservation techniques for supports. Polyethylene foam strips keep the individual elements in place, as seen in Figure 18. The foam can be ordered in rolls of 1/4" width or can be cut into strips from 1/2", 1" or even 2" or 3" plank, according to need. It is glued in place with hot melt glue.

Figure 19

Figure 20

Skulls and jaws are of great importance and their storage should reflect that. They should always be stored with the teeth up to prevent damage. Additional supports can be created around protruding teeth, such as the long canine teeth of Smilodon, for example.

The appearance of storage mounts is of more than esthetic value, it reflects the importance of the specimens and aids in considerate use by researchers. It should be simple to replace the specimen within the storage, again to enable the researcher to easily study the specimen.

All specimen trays are lined with 1/8" polyethylene foam. The small plastic boxes are lined as well, with 1/16" foam.

At YPM, we have masonite forms for the volunteers to use to cut the foam to the correct shape. The form, as you can see, is cut out at the corners, so that the foam comes up the side of the tray, just to the edge of the tray side. On the larger trays, edges are scored with the bone folder along a straight edge to make a sharp fold. The trays have been sized to nest within each other.

We use inert trays for most storage, however, we have a large pre-existing stock of un-buffered heavier weight trays that we continue to use for very heavy material. There seems to be no hard evidence that most fossils are harmed by acidic storage materials, and all trays are lined with polyethylene foam that will protect the specimen from contact with the tray.

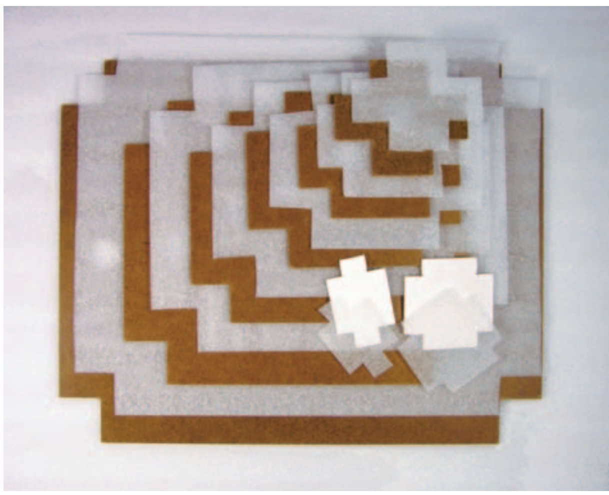


Figure 21

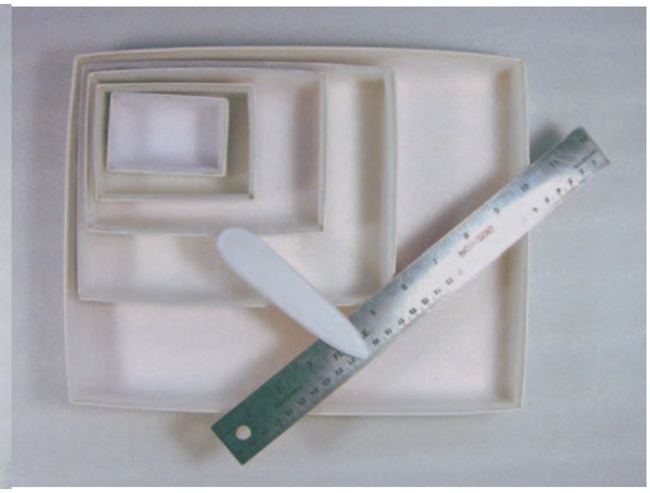
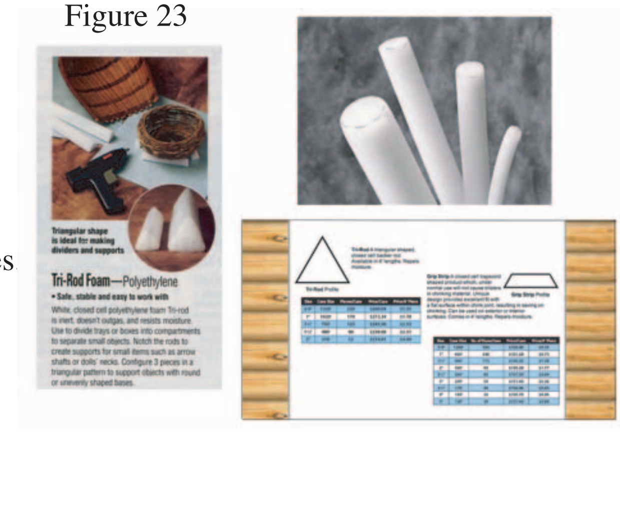


Figure 22

It should be noted that some foams have been noted to show deterioration of under strong UV light, showing yellowing and brittleness over time.

As the citation in the Boston Museum of Fine Art Conservation and Art Material Encyclopedia Online notes: Ethafoam® is lightweight, stable and has low emission of volatiles although, in general, polyethylene is susceptible to degradation, shrinkage and warping in direct sunlight.

Figure 23



Ethafoam brand has been extensively tested by conservators, however, other brands may be acceptable. Cell-Aire® has been mentioned in some conservation literature.

Closed cell polyethylene foam rod, known as backer rod, comes in a variety of shapes and sizes. It is available from conservation suppliers, and from log home building suppliers. Cut off bits of polyethylene foam plank can also be saved for use as edging and supports.

Large

Figure 24 These large specimens are unsupported, and rest on acidic, water absorbent paper.

Figure 25. For most heavy specimens at YPM we use a combination of a wood or MDF base and a supporting cradle of either polyethylene foam or plaster and foam.

"Woods contain varying amounts of acetic and formic acid, either free or chemically combined in compounds that can release the acid during aging."
from: Pollutants in the Museum, Practical Strategies for Problem Solving in Design, Exhibition and Storage, Pamela B. Hatchfield

Wood releases acids, especially in humid conditions. MDF is a compressed particle board, easily worked, but particle boards are known to emit urea- formaldehyde. It is preferable to use MEDEX or MEDITE II, which are formaldehyde free boards.

Specimens that have wood incorporated into their bases can be stored on open shelving, cutting down on the possibility of acid buildup that could occur in an enclosed space.   Additionally, most emissions are lessened at lower temperature and lower humidity. Formaldehyde levels, according to one study, were reduced by 40%, when relative humidity was reduced to 30%.

Figure 26. Longer, larger bones can either break under their own weight from lack of support or suffer from failure of old adhesives, again due to the stress of unsupported weight. In specimens collected in the 1800's to early 1900's these were often hide glues, but many specimens from the 1960's and 1970's were glued with Duco Cement or other failure prone adhesives.

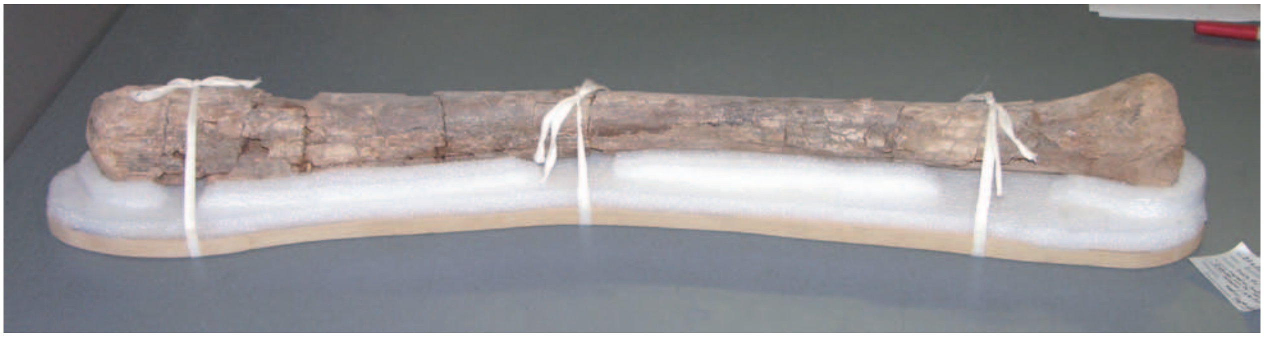
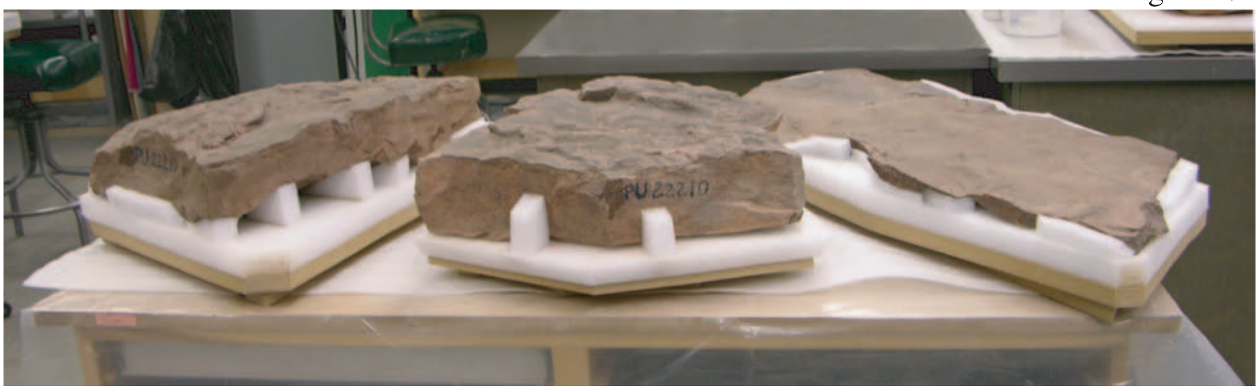


Figure 28.

Figure 29.



On long flat bases, the foam can be either built up around the specimen or cut to fit the specimen. The specimen can be tied to the base with archival cotton tying tape to prevent movement.

This is a typical method for storage gleaned from conservation literature.

The close up in Figure 30 shows the runners that have been incorporated into the YPM bases that hold heavy specimens. These have turned out to be very handy in the finger protection area, allowing staff to more safely move these specimens. The runners don't add much to the height of the base and have proven to be well worth the extra inch.

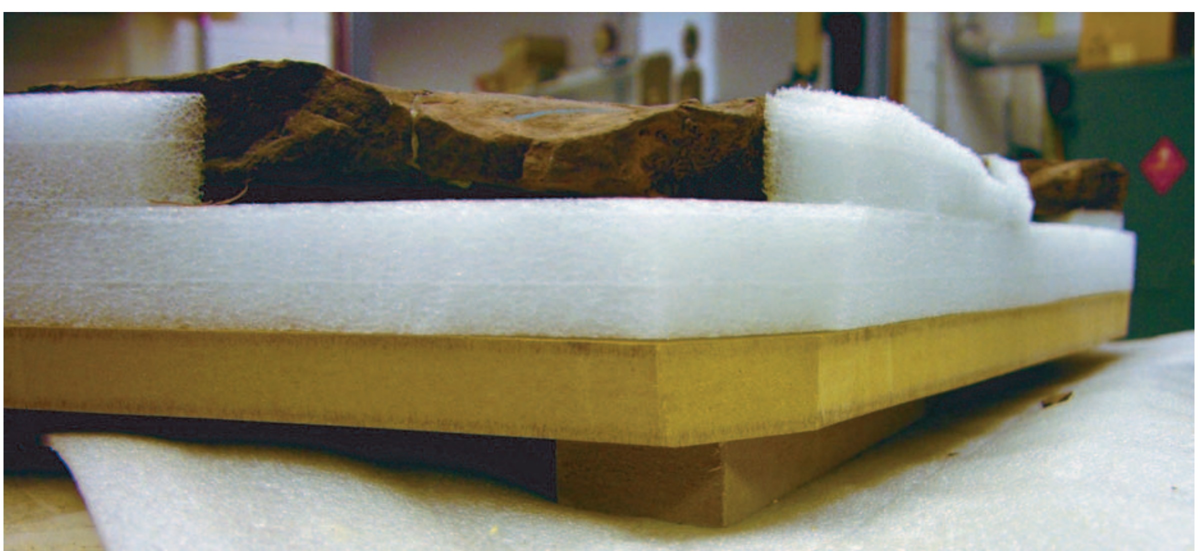


Figure 30

Very large - large skulls or limb bones

Figure 31. Specimens stored like this, with fragile processes unsupported, on acidic and water absorbent paper padding are in great danger of damage.

Figure 32.

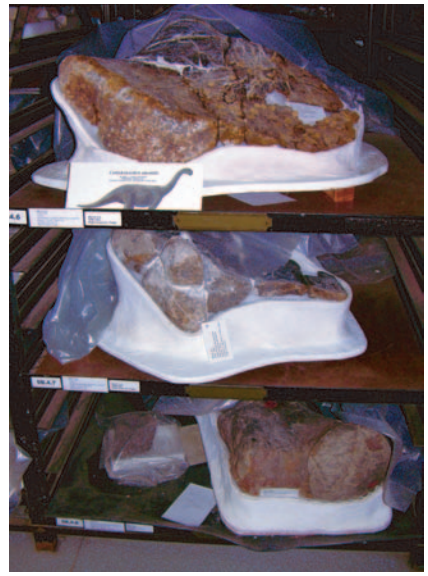


Figure 33.

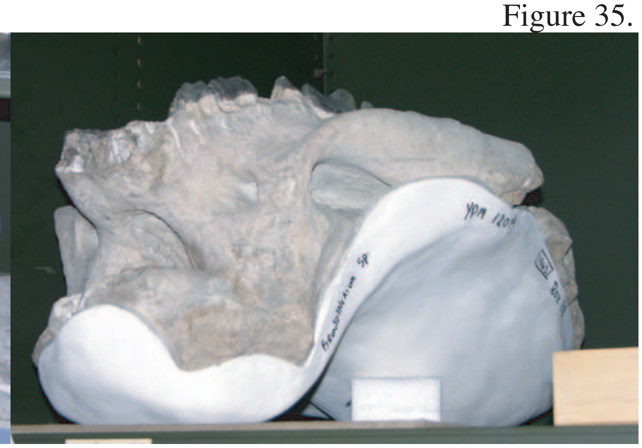
Due to space constraints and the style of the existing shelving, decided upon a simple open plaster, fiberglass, and wood bedding jacket as a storage support for the large specimens in the YPM Marsh Collection. This jacket style can be compared to the clam-shell type jackets described by Steve Jabo of the Smithsonian Institution.

Specimens that have been stored like the one below, sitting on its teeth, should be placed in new storage jackets that support the entire skull and leave the teeth up, both for ease of study and to prevent damage. Figure 35 is another type of jacket style that dispenses with the wooden base.

Many of these bases also incorporate electrical conduit as an additional support. It bends easily and gives good support for complicated shapes.

Figure 34.

Figure 35.



Following is a quick overview of YPM base making techniques. We developed this particular style of base, because of two factors. One is that we can make them easily, as all the steps are simple, and the other is that they use the least amount of space in collection rooms and still make the specimen available for research.

Figure 36. The cleaned and repaired bone is set up in the sand table, in the direction opposite from that in which it will be stored. In other words, mammal skulls are placed in the sandbox teeth down, so that when finally in their jacket, the teeth will be up.

Figure 37. The whole area is covered with thin plastic sheet, to protect the bone from the plaster and clay to be added later.

Figure 38. Plastilina clay is rolled out to the thickness of the polythylene foam sheet that will be used to line the jacket. We use 1/8" polyethylene foam, not Volara and not thick foam. We felt that Volara was too expensive for the quantity of bases we were making and we felt that support was preferable to padding. The clay is also used to fill any areas that might create undercuts in the jacket.

Figure 39. The clay is covered with aluminum foil, to prevent the clay from sticking to the plaster. The foil is cut to the edge of the clay and indicates where the edge of the plaster will be. Sometimes aluminum conduit is added for support.

Figure 40

Figure 41

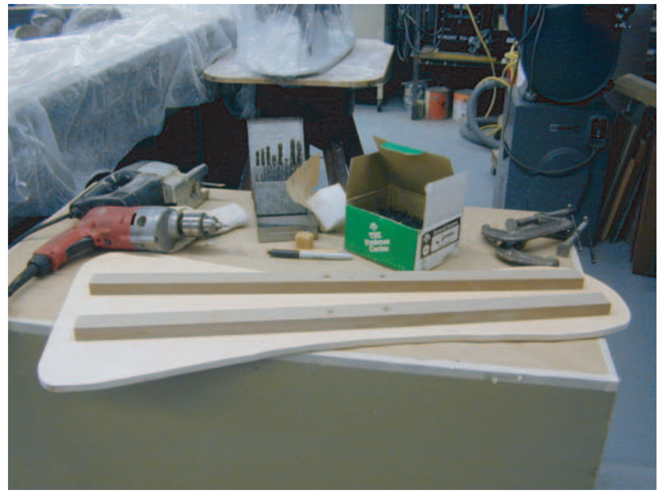


Figure 40. The wood or MDF base is cut to shape. This base extends 2 - 3" outside of the farthest edge of the bone, thus creating a sort of "bumper" for the bone itself. By having the wooden base create the "bumper" we can expose as much of the actual bone as possible for researchers, while still fully protecting the bone from being damaged through contact with other bones on the shelf.

Figure 41. Runners are added underneath the base with countersunk screws. These raise the base slightly, allowing room for fingers to extend under the base and help with lifting heavy specimens.

Figure 42. The base is ready to be attached. Large holes have been drilled into the base and sheet rock screws are screwed through and protude from the base. Both of these help to hold the plaster to the base, as wood and plaster expand and shrink at different rates.

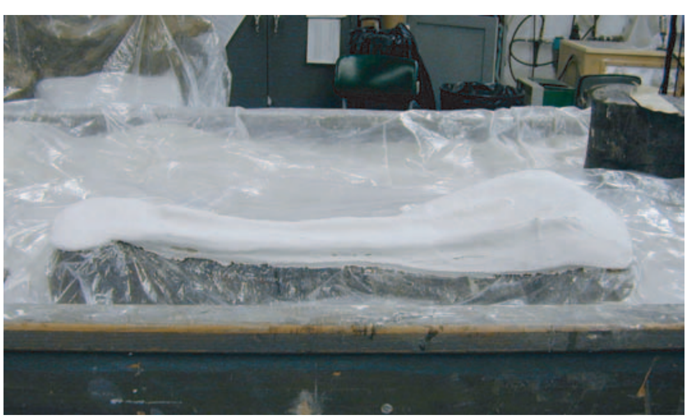


Figure 43. One layer of Hydrocal or Hydrocal FGR 95 plaster with chopped strand fiberglass has been added to this base, enclosing the pipes.

Figure 44. And then the base is plastered on. The fiberglass is well wrapped around the screws, attaching the base firmly to the plaster. The surface should be smooth and clean, partly for esthetics but also to make the jackets less painful to move around.

Figure 45. The finished and dried base is removed and the edges cleaned up with a sureform.

Figure 46. Once the plaster is thoroughly dry, the polyethylene foam is added. Rhoplex N580 is used as an adhesive. This is a PVA glue that remains sticky, so we use it as a contact adhesive. It is painted on both the plaster and the foam, let dry for about 10 minutes and then the two parts are stuck together. The fossil is not exposed to the adhesive.

Figure 47. The finished base. To view the reverse side the specimen is removed from the base and put into the sandbox.

Figures 48, 49, and 50. This specimen is now ready for storage. At YPM we created over 300 of these supports

Very often we can't change the basic storage - the shelves, drawers, temperature or humidity controls - but there are a lot of simple, effective, and not expensive things that we can do to protect the specimens that we have worked so hard to prepare. Any storage method needs to be maintained and updated over time. All storage materials have a life span, all will deteriorate over time. By our choices we hope to provide the safest storage we can for the longest time.

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A selection of references on materials and methods for storage

Information sources available online	URL
JAIC online	http://aic.stanford.edu/jaic/
Getty Conservation Institute, Art and Archeology Technical Abstracts	http://www.getty.edu/conservation/research_resources/aata.html
Western Association for Art Conservation	http://palimsest.stanford.edu/waac
CoOL – Conservation Online	http://palimpsest.stanford.edu/
Museum of Fine Arts, Boston, Conservation and Art Materials Encyclopedia Online (CAMEO)	http://cameo.mfa.org/
Bibliographic Database of the Conservation Information Network (BCIN)	http://www.bcin.ca/

Author	Title of article/book	Journal/Publisher/Volume	Abstract/Notes (edited from source)
Achhammer, B. G. R., Mary J.; and Reinhart, Frank W.	Study of degradation of polystyrene using infrared spectrophotometry.	Journal of research of the National Bureau of Standards 47, (1951), pp. 116-125, .	Mechanism postulated for the degradation of this widely used plastic.
Appelbaum, Barbara	Criteria for Treatment: Reversibility	Journal of the American Institute for Conservation, Volume 26, No 2, Article 1, pp 65-73, 1987	
Arni, P. G., G. C.Cochrane, and J. D.Gray.	The emission of corrosive vapours by wood, I:	Journal of Applied Chemistry15: 305–13. 1965a.	Survey of the acid-release properties of certain freshly felled hardwoods and softwoods.
Arni, P. G., G. C.Cochrane, and J. D.Gray.	The emission of corrosive vapours by wood, II.	Journal of Applied Chemistry15: 463–68, 1965b	The analysis of the vapours emitted by certain freshly felled hardwoods and softwoods by gas chromatography and spectrophotometry.
Bachmann, K	Conservation Concerns: A Guide for Collectors and Curators	Smithsonian Institution Press, 1992	
Bandes, S. J. ed.	Caring for Collections: Strategies for Conservation, Maintenance and Documentation	American Association of Museums, 1984	
Barclay, R. B., AndrÈ; Dignard, Carole; and Schlichting, Carl (Illustrator).	"Mount-making for museum objects."	Book. Canadian Conservation Institute (2002), . 74 p. (spiralbound) : 54 b&w ill., refs.	Provides advice, ideas, and technical information on the mounting of museum objects. Topics include: reasons for supporting objects; why some mounts fail; recommended stable materials (grouped as base materials; padding and finishing materials; retainers, fasteners, and miscellaneous) and their characteristics and working properties; unsafe materials; measuring methods; and mount design. A list of common mount-making tools and equipment is also provided
Bassett, Michael G. (Other)	Curation of palaeontological collections. A joint colloquium of the palaeontological association and geological curator's group	Book. Special papers in palaeontology n. 22. Palaeontological Association (1979), . 279 p. : ill., 24, 5 cm.	This publication incorporates the papers and the discussion presented at a joint colloquium of the Palaeontological Association and the Geology Curators Group which took place in Cardiff in 1978. None of the papers is concerned specifically with storage but several include sections on storage.
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Bertalan, S.	"Exhibit solutions at the National Archives: new materials for display supports."	The Book & Paper Group annual 15, (1996), pp. 1, .	At the National Archives and Records Administration, ragboard, acid-free corrugated board, and paper-based honeycomb panels are used to fabricate support for paper-based objects in display cases.
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Brunton, C.H.C., T.P. Besterman, and J.A. Cooper, eds.	Guidelines for the curation of geological materials	prepared by the Geological Curators' Group.: Geological Society, London, 1985	
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Chris Collins, ed.	The Care and Conservation of Palaeontological Material	1996?, Butterworth, Heineman	
Clarke, S. G., and E. E.Longhurst.	The corrosion of metals by acid vapours from wood.	Journal of Applied Chemistry11: 435–43. 1961.	
Colbert, Edwin H.	Inexpensive racks for the storage of large specimens	Curator, 4, pp 368-370, 1981	
Connolly, M. D.	Creating microenvironments in airtight cabinets—a warning: Statement of preliminary findings.	AIC Newsletter12(4):5–6. 1987.	
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Couch, Randall, Turbucz, Mihaly	Trays for Lining and Partitioning Wooden Storage Drawers	Journal of the American Institute for Conservation, Volume 22, No 2, Article 5, pp 92-97, 1983	
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		miscellaneous publications. Waddington, Janet and Rudkin, David M., Editors. Royal Ontario Museum (1986), pp. 81-83,	attached to a cardboard specimen label. This system will afford protection, provide easy visual access to data, allow the visual inspection of fossils without opening the containers, and maximize the number of fossils which can be kept in a drawer.
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