Article: Preparation of a fossil dinosaur
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PREPARATION OF A FOSSIL DINOSAUR

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Introduction

This paper is about an unusually well preserved, important and fragile fossil dinosaur, but it is also about a way to think about fossil preparation in general. This approach has been developed in collaboration with the objects conservators of the Anthropology Department at the American Museum of Natural History over the last eight years.

Fossil Preparation and Conservation

There are many ways to think about a fossil. A dinosaur enthusiast might imagine how an animal looked and behaved while it was alive. Vertebrate paleontologists are looking for morphological data, or evidence of evolutionary relationships. For the preparator, the specimen is a composite of materials which must be separated in order to make the data visible. Conservators are able to see the sometimes drastic nature of the treatments and understand the compromise between extracting the maximum amount of information and preserving the specimen as long as possible.

Both preparation and conservation are about controlling materials, and the bonds between the materials of which the artifact is made and materials used in preparation or treatment. Preparation of a fossil specimen is a process of breaking and creating bonds as elements are added and subtracted. An added material can permeate the entire system, form a thin surface layer, be a bed upon which the specimen rests or anything in between. CV Horie calls this "intimacy of contact" (Horie 1987) This paper shows how a collaborative relationship between a preparator and conservators enabled the author to manipulate bonding forces and intimacy of contact, and control the fragility of a particular specimen.

Figure 1. Specimen in-situ (skull to left, pelvis and femur to right).

The Specimen

The specimen (Fig. 1) was discovered in 1994 in the Gobi Desert of Mongolia, at a highly productive and now famous locality called Ukhaa Tolgod, by a joint expedition of the Mongolian Academy of Sciences and the American Museum of Natural History.

It is the job of the preparator to reveal what is hidden under the surface, and the first thing to emerge when the specimen arrived in New York was a beautiful skull (Fig. 1). This provided enough evidence to identify the fossil as a new oviraptorid dinosaur. In July of 2001, a description of the skull was published in the Journal of Vertebrate Paleontology and the new animal was given the name *Citipati osmolskae* (Clark et al. 2001).

Because this fossil is now the type specimen against which all other examples are to be compared, it is essential for every aspect of the morphology of every bone in the body to be photographed and described. This requires what is termed a complete preparation, in which the skeleton is disarticulated, and as much matrix as possible is removed, leaving the bone freestanding.

However, the bones are extremely fragile and will have to withstand repeated handling during photography and research. In addition, the specimen must also withstand the stress of removing the matrix which enclosed the bone, and these forces can be much greater and more localized than normal handling, such as the enormous force produced by the end of a sharp needle.

Unlike most fossils, the bones of this specimen are not infilled with other minerals. The mineral component of the bone has not changed much since the animal was buried, probably alive, in a wet dune-sand slide eighty million years ago (Loope et al. 1999). The organic component of the bone, however, primarily the bone collagen which gives tensile strength, has disappeared long ago. The bone mineral is a fragile network, surrounding a great deal of empty space, held together by relatively weak cohesive bonds that become even weaker when wet.

This delicate structure survived because of the natural packing qualities of the matrix. Deep within the matrix the bone is closely packed in a mass of sand grains held together by the bonding force of gravity and a little calcite cement. Even though the matrix can be unbonded easily simply by rubbing with the finger, it allows no internal movement, preventing the bone from collapsing. Visible in-situ are the parts of the skeleton which are eroding, in a weathered zone which extends about six inches below the surface. In this layer the natural unpacking of the matrix allows enough movement for disintegration to occur.

Field Jackets

Many fossil specimens would be impossible to collect without the addition of support materials, which often means the use of field jackets (what a conservator would call 'block lifting'). As this process can have a serious impact on the future well-being of the specimen, it is important to consider the strength and protective effect of the materials used. Because of logistical constraints *Citipati* was divided into six sections (Fig. 2) for removal and transport. The field jackets were constructed using the same basic techniques that vertebrate paleontologists have employed for over one hundred years. Inside these jackets are blocks of matrix containing the skeleton. The process starts with a layer of adhesive resin used to stop movement on the weathered side of the block. The resin used is a polyvinyl butyral, Butvar B76, which has a relatively broad solubility and is one of the most commonly used resins in fossil preparation. Copious amounts are applied in whatever solvent can be obtained locally. In the hot sun and constant wind of the Gobi Desert, the solvent quickly evaporates leaving a thick plastic coating on the surface. On top of the resin is a relatively thin layer of toilet paper and then a tough shell of plaster and burlap.

Figure 2. Specimen collected in six field jackets.

This traditional method of making a jacket, especially with a large and enthusiastic field crew, can unfortunately result in the plaster and burlap layer becoming so thick that the amount of force required to remove it presents a serious danger to the fragile, eroded bone under the surface. Ideally, jackets should be built up in thinner layers that could be peeled away without damaging to the specimen.

The only layer of these jackets that has consistently performed well is the Butvar. The resin when set is weakly cohesive, pliable, easily redissolved and does not adhere strongly to the bone. It performs very well as a temporary coating because the bonding forces of the Butvar B76 are the appropriate strength relative to the forces holding the specimen together.

Preparation of the Specimen

When the jackets were opened, and the individual bones removed from the matrix, it became apparent that some parts of the skeleton were more fragile than others, depending primarily on the shape of the bone and the degree of weathering. The digits, for example, (Fig. 3) are compact and blocky in shape, and were located deep below the weathered surface, so they were easy to prepare with just a light coating of Butvar.

Figure 3. Manus in preparation.

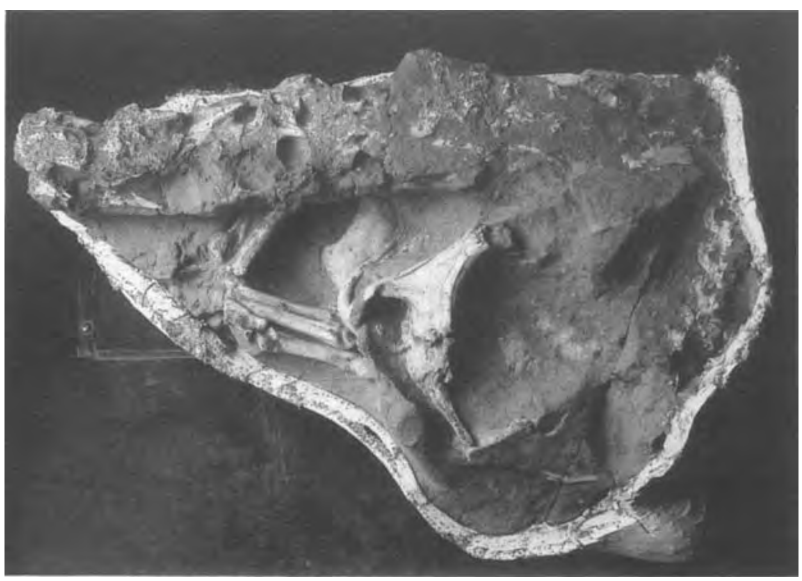

Figure 4. Thorax in preparation, weathered cervical vertebrae and cervical ribs exposed at top.

The vertebrae (Fig. 4) were more of a problem, especially where they extended into the weathered zone. They are tightly articulated and complex in shape, with long, flat processes winging out to the side. Preparation in this case may involve a lot of "creative breakage", reducing the vertebral column to smaller and smaller sections. To support the bone where it must not break, a variety of temporary supports are used (Figs. 5,6).

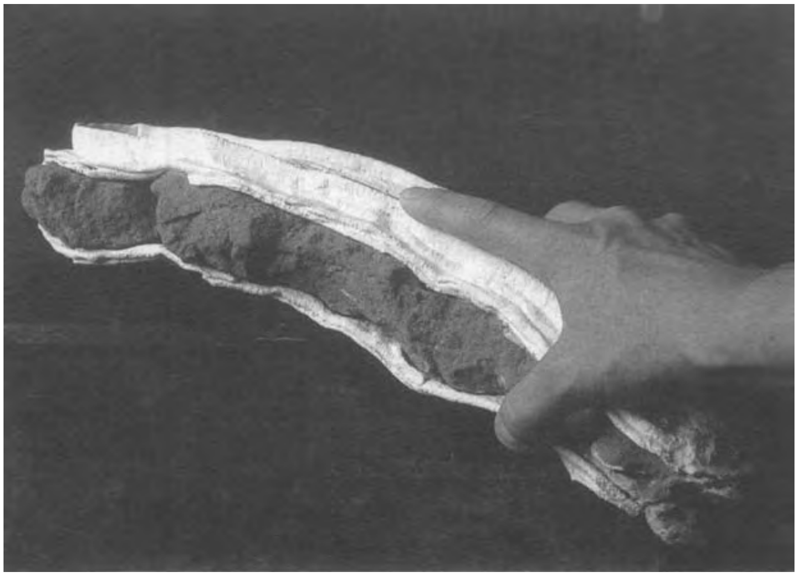

Figure 5. A plaster bedding sandwich held in place with finger pressure.

Figure 6. A wrap-around shell of foil and plaster bandage is peeled away as matrix is removed.

One possible support is a thick, temporary coating of Butvar, which in some cases is enough to withstand the stress of preparation and can then be easily removed (Fig. 7). This is one of the advantages of Butvar: it is a relatively weak and pliable adhesive which can peel away the last of the matrix, leaving a clean and undamaged bone surface. Later, a thin, long-term coating of Butvar is usually put on the clean surface.

Butvar can also be mixed with loose matrix to form a paste. This is used to build up artificial buttresses as long term supports for vulnerable areas, such as the cervical ribs (Fig. 8). Using a combination of temporary coating and buttresses, each vertebral element was strong enough to withstand gentle handling.

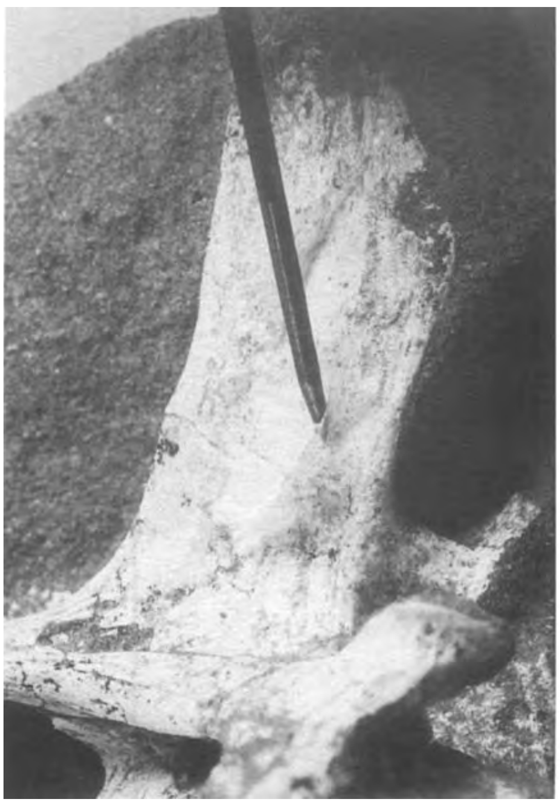

Figure 7. Caudal vertebra, with a thick coating of Butvar B76 being lifted off the surface of the bone.

Figure 8. Completed cervical rib, with Butvar B76 and matrix used as a paste.

Figure 9 shows the tail after preparation. The process, however, involved a great deal of breaking and the technique could probably be improved. An ideal treatment would target the skeleton in situ to strengthen the bones without increasing the cohesion of the matrix.

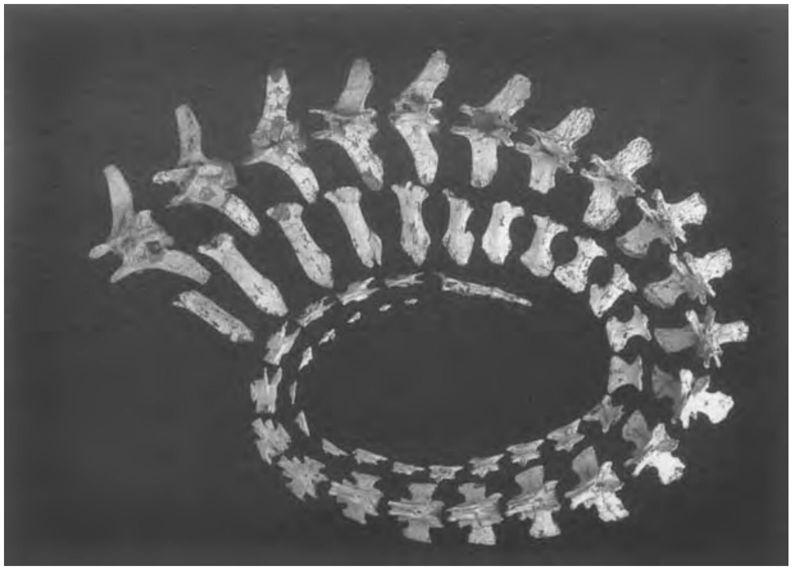

Figure 9. Completed tail.

The skull, unlike the vertebrae, cannot be broken during preparation, as this may destroy important scientific information. The exterior of the skull was relatively easy to prepare halfway (Fig. 10) while it was still supported by the matrix filling the interior. However, further preparation was not possible without bringing support material into very intimate contact with the interior of the bone - in other words, deep consolidation with a resin that would still allow the continued removal of matrix. At this point objects conservators were consulted about solvents, resins and application techniques. After discussion Butvar B76 was chosen as the resin, but applied in a vapor chamber, a bag filled with a solvent atmosphere, in this case ethanol and toluene vapors. The use of the chamber slows down the evaporation of the Butvar solution and allows the resin to set within the bone rather than migrating back up to the surface.

This worked for the cranium (Fig. 11), which also has the advantage of a good shape for handling. The jaw (Fig. 12) however, being U-shaped, was bound to snap eventually and when it did the cross-section showed that the resin was not in completely intimate contact with the interior: a shallow consolidation graded into a coating. The jaw was rejoined with the addition of a Plexiglas rod for reinforcement, which worked well.

Figure 10. Skull before treatment.

Figure 11. Completed cranium. Deep consolidation allows disarticulation and removal of excess matrix.

Figure 12. Completed lower jaws.

The long thin bones of the skeleton are the most likely to break, especially if they are eroded. For example, the large, heavy tibia and fibula (Fig. 13) were almost completely free of matrix when they collapsed under their own weight. Again, the cross section (Fig. 14) was informative. These bones were in the weathered zone of the matrix and showed extensive cracking and delamination as well as roots growing into the interior of the bone. This situation requires a lot more than shallow consolidation and this continues to be a problem. Deeper consolidation of the more massive long bones of the skeleton with a solvent-based resin has not yet been accomplished. Some preliminary tests using silanes, however, have produced promising results.

The ribs also have a problematic long and skinny shape, but because they are less massive they can be consolidated successfully by immersion in a resin solution, For the present Butvar B76 in ethanol is being used, but Butvar B98, which has a lower molecular weight and lower viscosity at the same concentration, is being considered as an alternative.

To consolidate the ribs by immersion, a short term, temporary support is needed in order to remove each rib from the body and prevent damage while the bone is wet and weak. After the rib is dry, it must also be possible to remove the support using minimal force.

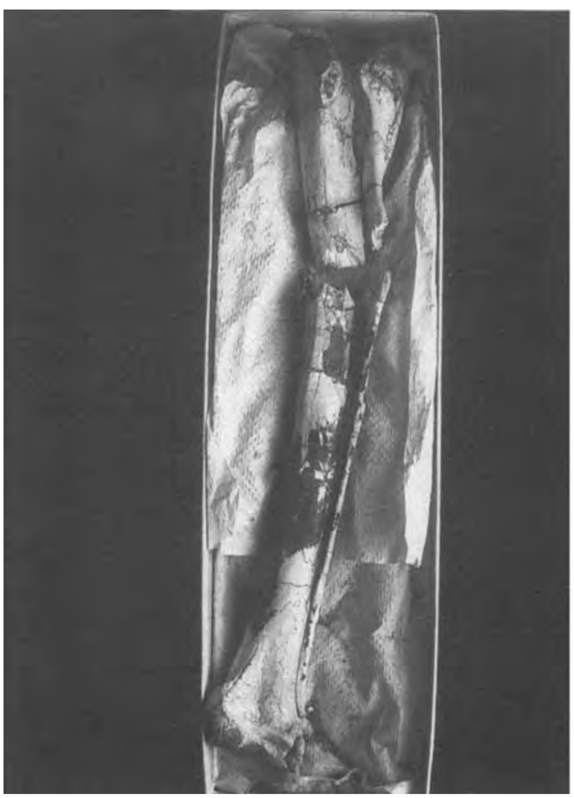

Figure 13. Broken tibia and fibula.

Figure 14. Cross-section detail.

The bones were protected with a layer of aluminum foil, and over this a mini-jacket of fiberglass (with Plexiglas rods added as necessary) was applied to the rib to serve as a temporary support (Fig. 15). The fiberglass had to be bonded with a resin which would not be affected by the ethanol in the Butvar solution but could be easily dissolved in another solvent - preferably acetone rather than a more toxic material. To the surprise of the author, the choice of the conservators was cellulose nitrate. This is the primary component of Duco cement, a material preparators avoid because it is known to age so badly. In this application, however, it never comes into direct contact with the specimen, and is removed before it has a chance to age. Cellulose nitrate is absolutely insoluble in ethanol, but very soluble in acetone, and was very successful.

Figure 15. Ribs after application of mini-jacket.

After the rib was removed and the jacket trimmed back (it has a consistency similar to fingernails and trims easily with scissors), the excess matrix was removed to provide access for the consolidation (Fig. 16). It was necessary to make absolutely certain that there would be no movement while the bone was wet, and the structure of the original matrix provided a good model. The specimen was re-buried in a new 'matrix' of glass marbles (of the type used by florists) instead of sand grains (Fig. 17). The Butvar solution was poured in and then siphoned off after 24 hours. Because the marbles have minimal contact with each other and the surface of the bone, they are easily separated afterwards.

To date only one rib has been successfully treated in this manner (Fig. 18). The depth to which the resin penetrated is still uncertain, and further experimentation and testing is needed to ensure that the behavior of the materials is understood, but considerable progress has been made.

Figure 16. Treatment of rib: mini-jacket trimmed.

Figure 17. Rib immersed in 'matrix of marbles

Figure18. Completed rib.

Conclusion

Unfortunately, fossils cannot be suspended in space during treatment (Fig. 19). However, this productive collaboration with conservators has already contributed to an increased understanding of materials and the development of new techniques for the preparation of fossils. The author hopes that fossil preparators and objects conservators will continue to work together for the benefit of the science of Vertebrate Paleontology.

Figure 12. An ideal setup for treatment.

Acknowledgments

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Suppliers

Butvar B76: Talas, 568 Broadway, New York, NY 10012, Tel: (212) 219-0770, Fax: (212)219-0735, (www.talasonline.com).

Duco cement: Hardware and office supply stores.

Glass marbles: Local florist supply store.

Plexiglas rod and fiberglass cloth: Local plastic supply store

References

Clark, J.M., Norell, M.A., and Barsbold, R. 2001. Two new oviraptorids (Theropoda: Oviraptorosauria), Upper Cretaceous Djadokta formation, Ukhaa Tolgod, Mongolia. *Journal of Vertebrate Paleontology* 21(2):209-213.

Horie, C.V. 1987. Materials for conservation: organic consolidants, adhesives and coatings. London: Butterworth-Heinemann.

Loope, D.B., Mason, J.A., and Dingus, L. 1999. Lethal Sandslides from Eolian Dunes. *Journal of Geology* 107:707-713.

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