Applying a conservation model to the treatment of fragile dinosaur bone

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The Challenge

The American Museum of Natural History in collaboration with the Mongolian Academy of Science has been excavating the locality Ukhaa Tolgod in the Gobi Desert of Mongolia, a site rich in late Cretaceous specimens. Much of the fossil bone, although well preserved, is very fragile due to the loss of all organic components yet lack of permineralization of void space, leaving the bone porous and weak. Research necessitates that the bones be completely exposed; however, in many cases these particular fossil specimens are so fragile that they cannot withstand handling or even support their own weight when removed from the matrix. In these cases, previous attempts at consolidation with Butvar® B-76 (polyvinyl butyral) were unsuccessful, primarily due to lack of penetration of the adhesive.[1]

A consolidant is needed that:

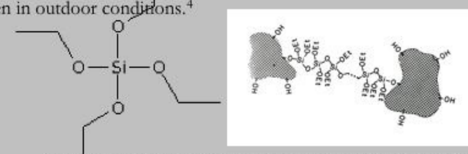
- Completely penetrates the bone within the matrix
- Will not interfere with subsequent matrix removal
- Imparts adequate strength to the free standing bone
- Has good long term stability

A Possible Solution: Conservare® OH 100

An investigation was undertaken into potential consolidants. The most promising found was Conservare® OH 100 (ProSoCo, Inc.), which is most typically used to consolidate architectural stone. This consolidant has many desirable properties; most importantly, it has an extremely low viscosity, and hence is able to penetrate deeply and evenly into the substrate.[2] Additionally, it remains fairly brittle when set, suggesting the ability to be crushed for continued matrix removal.

Conservare® OH 100 contains primarily the monomer tetraethoxy silane (TEOS), and sets by polymerizing *in situ*.[3] This consolidant has been extensively tested, and has been found to have good long term stability in terms of the consolidation effect and strength increase of treated samples, even in outdoor conditions.[4]

Detail of a long bone which broke after unsuccessful consolidation with Butvar B-76, even after a full immersion treatment



TEOS monomer and an illustration of the polymer formed between sand grains, from Lewin, S.Z. 1988. The current state of the art in the use of synthetic materials in stone conservation. in: *The deterioration and conservation of stone: notes from the International Venetian Courses on Stone Restoration.* Unesco: Paris, *pp. 290-302.*

Conservation Model

The conservation model ensures the highest possible standards in the treatment of objects. These include:

Scientific testing

Documentation

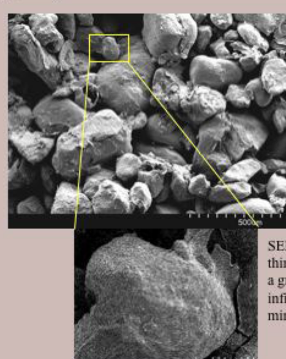
Preventive conservation

Scientific Testing

Before treatment of an actual specimen, Conservare® OH 100 was tested on unassociated samples from the same locality. Tests included:

- Condition assessment before and after treatment
- Scanning electron microscopy (SEM)
- Microhardness testing

Upon examination, treated samples were found to have a marked increase in bone strength, while the matrix remained easily removable.



SEM of consolidated matrix (top) with detail showing a thin coating of the Conservare OH 100 onto the surface of a grain of sand (below). Conservare® OH 100 does not infill the large voids between grains, so the matrix was minimally consolidated.

Hardness testing is a common mechanical test used to assess the physical properties of materials through resistance to permanent indentation.[5] Hardness was measured on small bone samples ($<1mm^2$) before treatment and during cure. These results were used to devise the optimal application procedure for Conservare® OH 100.

Documentation and Treatment

The fossils were documented with color slide photography, digital images and a written report at all stages of treatment, with specific information on all materials and methods used. Before treatment, the partially exposed bones were supported in sand to minimize risk of collapse while wet. The Conservare® OH 100 was drip applied using two applications separated by a one hour interval, and then allowed to sit for two months. This treatment procedure was chosen because micro-hardness results indicate that this application procedure resulted in greatest strength increase, and that this time period is necessary for full cure. After full cure, the specimens were prepared using normal procedures.

Long Term Storage

Specialized mounts were designed to to minimize riskin storage and during study.

Storage box were prepared from Tyvek® (spunbonded polyethylene), Plastazote® (polyethylene foam) and polyester batting in acid free cardboard boxes, supplied by University Products. Each specimen was also numbered with Pelikan India Ink between B-72 barrier layers.

Conclusion and Future Steps

By applying a conservation model, a new material was safely and successfully employed to treat these particular specimens.

Conservare® OH 100 has not previously been used on bone, and current research is ongoing to more fully understand the mechanism of bonding.

While this consolidant was appropriate for this particular application, similar research and testing should be carried out before use on other specimens.

References

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2. Domaslowski, W. 1987. The mechanism of polymer migration in porous stones. *Weiner Berichte uber Naturwissenschaft in Kunt. (4)*:402–425.
3. *Conservare® OH 100 Consolidation Treatment;* MSDS; ProSoCo Inc.: Lawrence, KS, July 28, 2000.
4. Wheeler, G. 2005. *Alkoxysilanes and the Conservation of Stone.* Los Angeles, CA: The Getty Conservation Institute.
5. Boyer, H. E. 1987. *Hardness testing: from material compiled by the ASM Committee on Hardness Testing*. Metals Park, OH: ASM International.