Effects of Fossil Consolidation on Potential Future Scientific Research

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Abstract

As part of dissertation research into the effects of conservation treatment on the scientific value of specimens, a case study of a subfossil mammoth tusk treatment was used to evaluate the often conflicting needs for preservation with a specimen's potential for scientific research. The tusk was retrieved from a marine environment and considered for display during the Royal Albert Memorial Museum's HLF 2007-2011 redevelopment. Ultimately it was set aside due to condition issues stemming from incomplete fossilization and limited initial stabilization. It was hoped that if the tusk was not going on display, it could be analyzed. However, it required treatment to enable handling and to go into storage. As consolidation is one of the methods used for stabilization, an investigation was conducted into how commonly used consolidants and solvent combinations at several concentrations might impact different types of analysis. The investigation methodology included literature review, consultation with a fossil preparation expert, and SEM-EDS Imaging of consolidated tusk samples. After examining several avenues of analytical impact and what could realistically be achieved, a treatment methodology was formed based on data gathered from the investigation that balanced the museum's desire to have the tusk stabilized with eligibility for future analysis.

Background

Subfossil Mammoth Tusk: The fossil (RAMM accession number 301/2006) dates between the Paleocene and the Holocene, and measures 1000mm x 100 mm diameter. It was retrieved in 2006 along the north coast of Devon and was considered for display (H. Morgenroth *pres. comm.* 1 June 2012). Sub-fossil bone is bone that has not completely mineralized and "lacks the strength of either original bone …or of permineralized fossil bone" (Shelton & Johnson 1995, 59). Since the fossil's condition made it difficult to handle, it was put forward as an intern project (A. Hopper-Bishop *pres. comm.* 5 October 2011).

Tusk before being unwrapped.

Dissertation: The MSc dissertation focused how conservation training approaches significance and value primarily within a cultural construct and how this impacts a conservator's assessment of the value of natural history specimens. It also addressed how conservation treatment affects a specimen's scientific value and discussed the current research on the effect of conservation materials and methods on scientific analysis, especially for historic specimens.

Fossil Condition

Subfossil mammoth tusk before treatment and detail of delaminating dentine.

The tusk was in poor condition. This was primarily due to partial fossilization, and a lack of controlled drying and desalination after retrieval. Challenges included: fragile, unstable, and flaking surface and structure; delamination of the surface layer and between the dentine layers; accretions and encrustations such as sand; possible salts contamination; and the heavy weight of the tusk. The tusk was also wrapped in cotton medical tape, which caught on the rough surface and made it difficult to see and avoid fragile areas while handling.

Research Interest

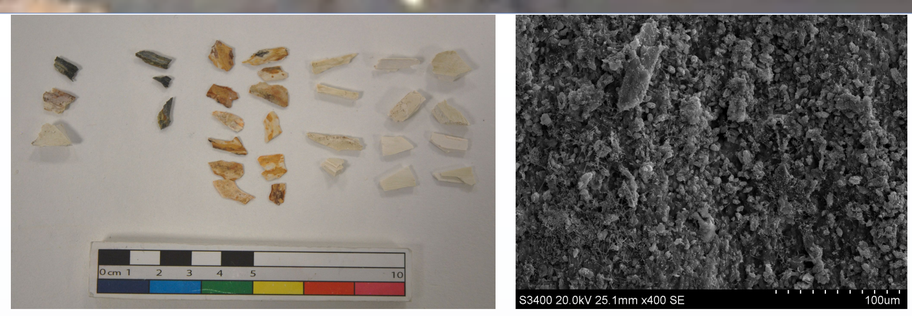
Fossils fulfill a variety scientific research purposes: education, cast and mold making, morphological and bone structure study, tomography, topography, isotope analysis, radiocarbon dating (C14), ancient DNA sequencing, and display (López-Polin 2011; Shelton & Johnson 1995). It was hoped that the tusk might be used for ancient DNA sequencing, but there was concern that treatment might impact any future research value. During initial literature review, Fernández-Jalvo and Monfort (2008), López-Polin et al. (2008), and López-Polin (2011) discussed how conservation treatment may affect the analytical methods used to study fossilized bone. The technique of consolidation, which is common in fossil preparation (López-Polin 2011), can greatly obscure the topography of a fossil. However, these studies did not disclose the consolidation concentrations used. Any treatment would need to balance the need for stabilization with what might be realistically achieved in terms of analysis for the tusk.

Methodology

Fossil Preparation Expert Consultation: Sarah Finney from the Sedgwick Museum of Earth Science in Cambridge, UK, was consulted for her recommendations on fossil preparation.

Literature Review: A literature review was undertaken as part of the broader dissertation topic. The part of this review focused on fossil preparation, types of analysis, and how these forms of analysis might be impacted by commonly used conservation materials for consolidation.

SEM Imaging: Detached tusk fragments consolidated with Paraloid B72 and Mowital B30H/Butvar 98 (polyvinyl butyral) were imaged with a Hitachi S-3400N SEM (EDS Oxford Instruments INCAX-Sight Probe not used). The listed consolidants were readily available at RAMM, commonly used in fossil preparation, and would not reintroduce water that might damage the specimen (Appendix G; Shelton & Johnson 1995, 59). Consolidants were prepared as recommended by the American Museum of Natural History's PaleoPortal Fossil Preparation Website. Paraloid B72 was dissolved in acetone and in xylene at 2%, 5%, and 10% w/v concentrations. Mowital B30H was dissolved in Industrial Denatured Alcohol at 2%, 5%, and 10% w/v concentrations. Each consolidant was applied to half of each sample via brush or pipette. The samples were then gold coated to increase resolution. SEM images were taken at x20, x100, x200, x400, and x800.



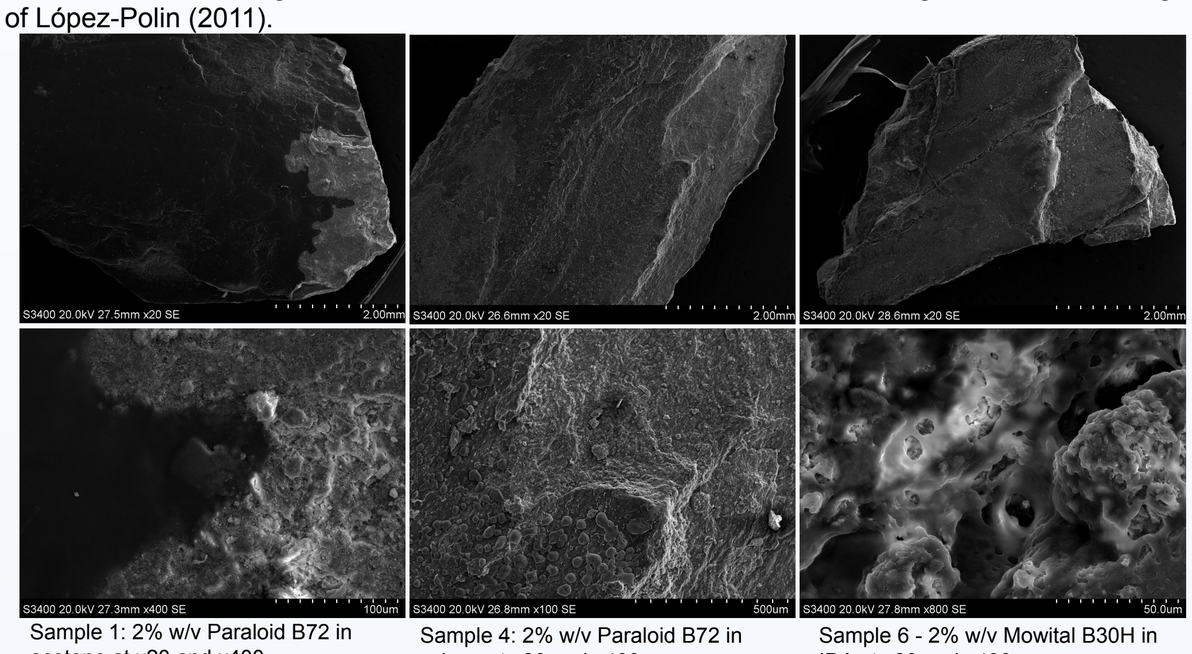
Three controls and 27 detached fossil pieces used as samples for SEM Imaging. Example of control at x400.

Results

Consultation: Sarah Finney suggested that DNA sequencing was unlikely, but isotope analysis had potential. Finney only suggested treating the fossil if it was going into a controlled, stable storage environment.

Literature Review: While López-Polin (2011, 4) makes the case for minimal to no consolidation for fossils that are stable and may be used for topography, consolidation does not appear to impact isotope analysis. Stephan's (2000, 533) study concluded that "No influence on the preparation and measurement of the oxygen isotopes was observed for samples treated with four different consolidants nor was there any clear relation between δ18 O values and state of preservation".

SEM Imaging: Even at the lowest percent concentrations, there was visual alteration to the surface at the microscopic level. Consolidation caused darkening, obscured or smoothed surface features, and resulted in an uneven coating in some areas. Paraloid B72 mixed with xylene performed better, however small globs of consolidant formed on the surface, confirming some of the findings of López-Polin (2011).



Sample 1: 2% w/v Paraloid B72 in acetone at x20 and x400.

Sample 4: 2% w/v Paraloid B72 in xylene at x20 and x400.

Sample 6 - 2% w/v Mowital B30H in IDA at x20 and x400.

Treatment and Conclusions

Using the results from the consultation, literature review, and SEM Imaging, a treatment was devised for the subfossil mammoth tusk that would allow for future isotope analysis while improving the tusk's stability. Xylene was used for the SEM imaging due to its low polarity and extended evaporation time allowing for deeper penetrations. However, due to health concerns and limited fume hood space, Industrial Methylated Spirit was substituted as it would decrease the evaporation rate of acetone and increase the consolident's penetration. In the end, a 3.5% w/v solution of Paraloid B72 dissolved in an 80:20 ratio of acetone/IMS was selected. Consolidation was applied in two coats, focusing on structural cracks, fragile/crumbling areas, and at each end of the tusk. Only unstable areas on the outer surface were consolidated. After consolidation, the tusk was stored in a controlled environment per Finney's suggestion.

Subfossil mammoth tusk after treatment and detail of stabilized dentine.

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