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Fluorescence Mapping of Materials on Mammut Americanum

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Introduction

- *Mammut Americanum*, more commonly known as the American Mastodon, is an extinct species found throughout North and Central America. Dated from either the Aftonian or Yarmouth age (120,000 to 200,000 B.C.E.), a 12-foot, 600-pound tusk of a mastodon was discovered in Hampton, Iowa in the 1930's.
- In 1933, it was brought to the University of Northern Iowa for comprehensive research and preservation. The tusk was covered in unknown materials such as varnish, spackle, lacquer, and shellac in an attempt to preserve it before putting it on display in the UNI Museum in the 1960's.
- Currently, the tusk is in two pieces, the smaller of which was the subject of this research.
- Fluorescence mapping of the materials on the Mastodon tusk is a necessary study as the lacquers hold the key to determining the future preservation methods required by the tusk.

Figure 1 – Tusk Undergoing Research[1]

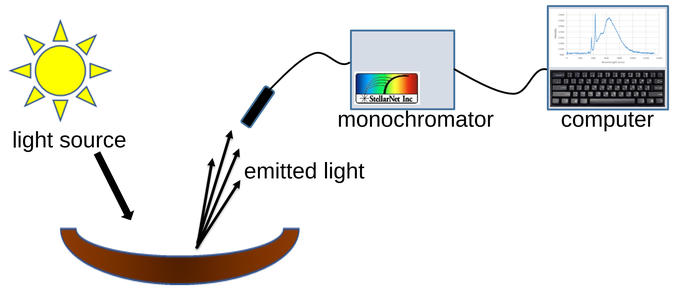
Methodology

- The tusk was given an orientation and a grid was placed over the tusk and labeled alphanumerically. Each grid square had a unique designation for mapping. Three sections of the tusk were identified for analysis by fluorescence: the shellac, the plaster, and the dental or tusk material.

Figure 2 – Fiber Optic Set-Up Used to Gather Fluorescence Spectra

- A blacklight was used to excite the fluorophores at which point the detector collected then re-emitted light signals which were converted to spectra.
- Fluorescence is a luminescent process in which a photon is absorbed at one wavelength then re-emitted at a longer wavelength. An electron, upon absorption of a photon, is excited to a higher electronic state while maintaining its spin orientation. This process, known as excitation, occurs in 10^{-12}-10^{-15} seconds. Emission, the second event in fluorescence, is the re-emittance of a photon of longer wavelength in 10^{-9} seconds as the electron relaxes back to the ground state.
- Fluorescence spectroscopy is more selective than both UV-Vis and IR spectroscopy. Since every molecule does not fluoresces, this selectivity allows for a more specific and detailed analysis of the materials. This technique is also non-invasive which is beneficial considering the rarity and age of the Mastodon tusk.

Instrumental Design



- The instrument consists of five main parts: a light source (365 nm blacklight), an external sample (tusk), a monochromator, a detector (fiber optic fluorescence spectrometer with tripod mount), and a computer.
- The spectrometer used for this research had a UV filter to eliminate background. The range of the spectrometer is 250 to 1150 nm with a spectral resolution of <1 nm.
- A blacklight of 365nm was used which provided improved contrast compared to the blacklights used in prior research.

Results

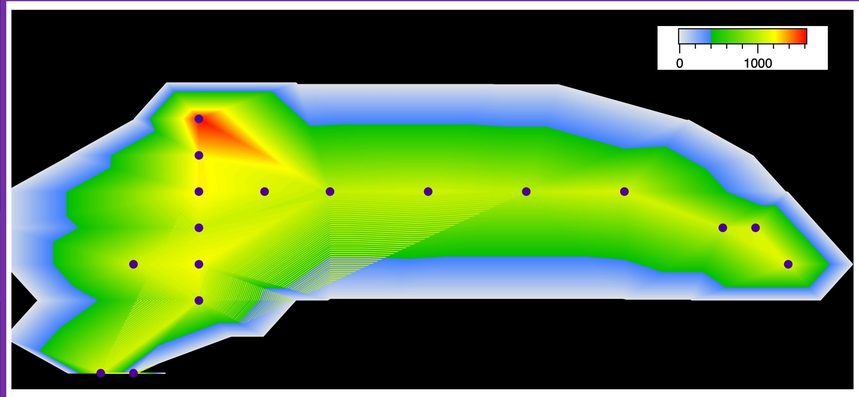


Figure 3- Fluorescence Relative Intensity at 675nm Across the Tusk

- Figure 3 shows the fluorescence intensity across the tusk at 675 nm. This shows that the plaster fluoresced most intensely while the shellac and the dental material fluoresced with relatively the same intensities.

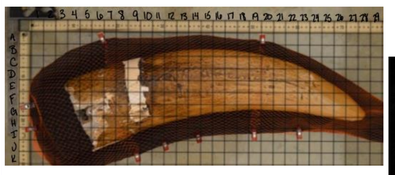


Figure 4 – Virtual Grid Mapping of Tusk

- Figure 4 shows the virtual grid created for the tusk which was used to identify points where data was collected.
- Figures 5 and 6 show the fluorescent nature of the tusk under the 365 nm blacklight. It distinctly shows the shellac, plaster, and dental materials.

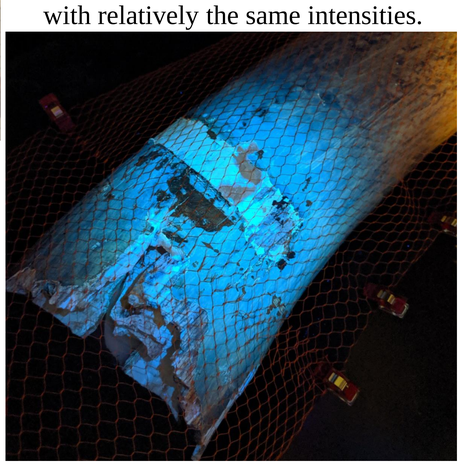


Figure 5 – Fluorescence of Plaster and Dental Material

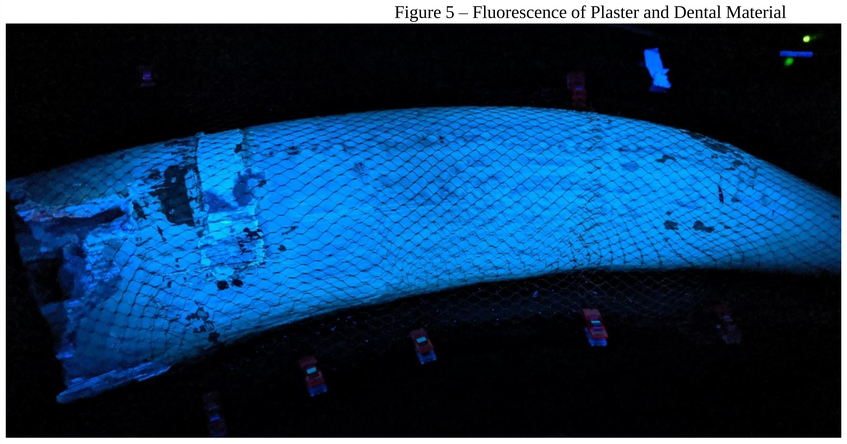


Figure 6 – Fluorescence of Tusk Under 365 nm Blacklight

Results

- Figure 7 displays the layers present on the tusk. The spectra of the three layers analyzed by fluorescence spectroscopy is displayed in Figure 6. The brown lacquer present on the tusk just below the layer of shellac does not fluoresce.

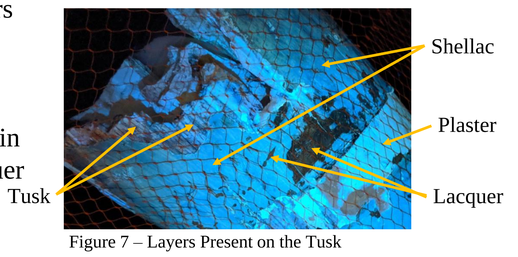


Figure 7 – Layers Present on the Tusk

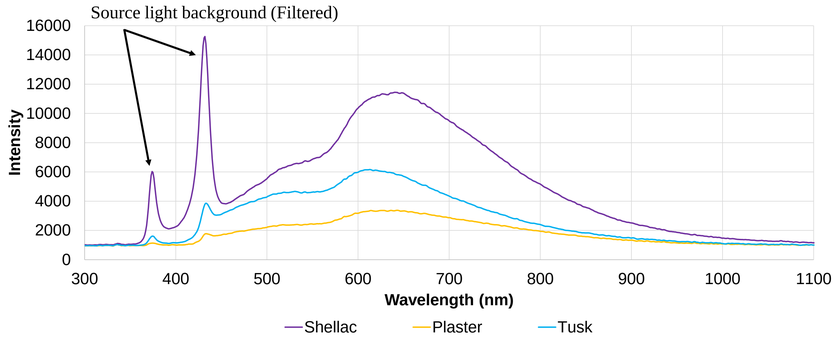


Figure 8 – Fluorescence Spectra of Three Tusk Materials

- Figure 8 shows the fluorescent intensity of 3 of the 4 materials present on the tusk – the shellac, the plaster, and the tusk material.
- The shellac, which fluoresces blue, fluoresces with the greatest intensity. The magnitude of the fluorescent intensities of the tusk and plaster are much lower.
- The plaster and the tusk materials have approximately the same contour of the shoulder between 500 nm and 600 nm while the shellac has a different contour. The shape of the plaster and the tusk spectra show they have a similar fluorescent nature with different intensities.
- The lacquer present on the tusk does not fluoresce so no data was gathered to map the lacquer.

Conclusion

- Fluorescence spectroscopy showed that three of the four materials present on the tusk are fluorescent – the shellac, the plaster, and the dental or tusk material. The lacquer present on the tusk does not contain fluorophores and therefore does not fluoresce.
- The spectra show that the plaster and tusk have similar fluorescence although they are not covered in the same material. Future work will need to be done to determine why the shapes are similar.
- The fluorescent map of the tusk created as a result of this research can provide a starting point for building more in-depth maps of the rest of the tusk.
- The spectra taken along different grid points on the tusk can also inform conservationists as to a satisfactory method to better preserve each portion of the tusk based on the material present. If the map and spectra are utilized properly in future research, the tusk could be displayed in the UNI Museum for future generations of students, faculty, and guests to enjoy.

Acknowledgments

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- University of Northern Iowa Museum
- Roy J. Carver Charitable Trust
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Work Cited

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4. UNI Museum 'Unveiling the Tusk' exhibit showcases Iowa mastodon tusk; 2019