Fall 2019

Mapping the Exterior of a Mastodon Tusk using UV-Vis Diffuse Reflectance

Teresa Feldman
University of Northern Iowa, feldmtaa@uni.edu

Mapping the Exterior of a Mastodon Tusk using UV-Vis Diffuse Reflectance Spectroscopy

Teresa Feldman

Department of Chemistry and Biochemistry, University of Northern Iowa, Cedar Falls, IA

Background

The 12-foot, 600-pound mastodon tusk was discovered in Hampton, Iowa, in the 1930s by a man digging in the gravel. It was the largest discovered mastodon tusk until the 1970s. The tusk was donated to UNI in 1933, under Dr. Cable, and put on display at the UNI Museum in the 1960s. Over the years, there have been many efforts to conserve the tusk, but it has still sustained breakage and water damage. It has also been subject to inadvertent degradation from some of the previous conservation efforts.

Figure 1. Display of mastodon tusk at UNI museum.[1]

The purpose of the research conducted was to create a spectral map of the lacquers on the mastodon tusk at the UNI Museum. To accomplish this, a spectroradiometer with a diffuse reflectance tip was used to non-destructively collect UV-Vis spectra. In order to create a coordinate system for the mapping, a grid map was made for the tusk. Creating a UV-Vis map of the lacquers on the tip of the tusk will allow conservationists at the UNI museum a better understanding on how to proceed in their preservation of the tusk.

Methodology

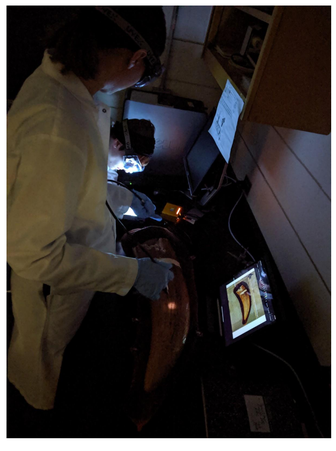

Figure 2. Spectra being collected from the tusk

- To collect UV-Vis spectra from the tip of the tusk, a Stellar-RAD handheld spectroradiometer was used with a diffuse reflectance accessory tip.
- The tip of the tusk was brought to the laboratory where it was analyzed with the instrument at room temperature.

- A virtual grid was created to provide a way to record areas where spectra were taken.
- Spectra were taken from representative points or points with unique characteristics.

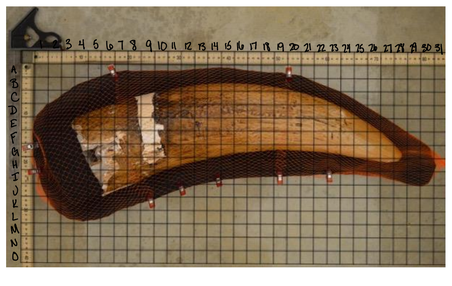

Figure 3. Grid of tusk used for creating coordinate system

Instrumentation

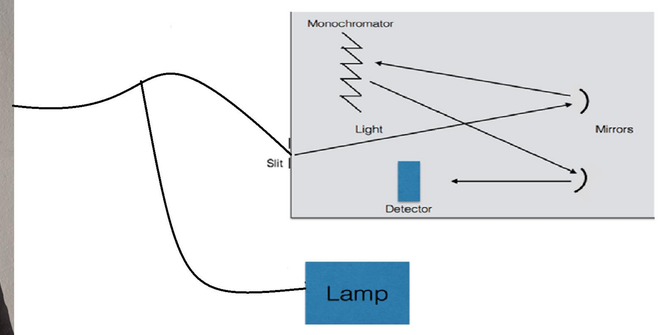

Figure 4. Diagram of spectroradiometer

- Diffuse reflectance occurs when a surface that is not very smooth results in a combination of refraction, reflection, and diffraction of the impinging light.[2]
- UV-Vis spectroscopy is measured through electronic transitions that take place in the UV-Vis regions.
- This is due to the absorbance of radiation by chromophores, which are functional groups that contain valence electrons with fairly low excitation energies.

- The spectroradiometer offers a range from UV-NIR (250nm-1150nm), but only the UV-Vis range was used for research.
- The handheld spectroradiometer offers a wavelength accuracy of less than 0.25 nm, with a spectral resolution of less than 1 nm.
- The fiber optic probe with the diffuse reflectance accessory attached emits light from a lamp, and the reflected signal is collected by a detector in the probe before being passed through a slit.
- The light is reflected by a mirror to a diffraction grating (monochromator), which separates the photons by wavelength before the light is dispersed to a focusing mirror, and is then reflected into the detector.

Results

There were two main types of materials that produced markedly different spectra: the shellac and the plaster beneath. The top lacquer reflected much less of the light when compared to the layers underneath. The figure below shows the spectra characteristic of the two main areas.

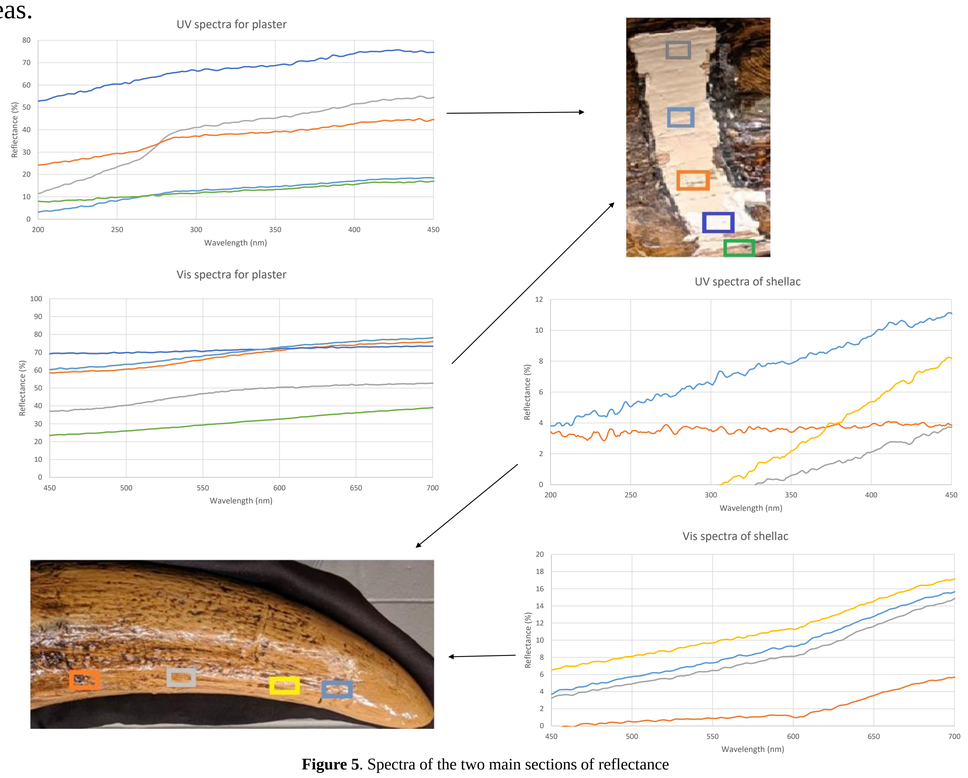

Figure 5. Spectra of the two main sections of reflectance

Results

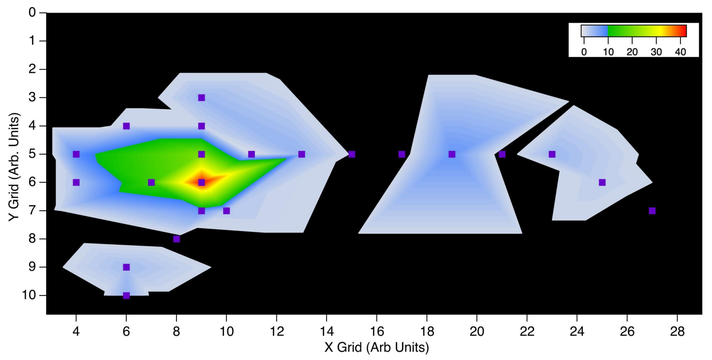

Figure 6. Mapping of UV reflectance at 300 nm

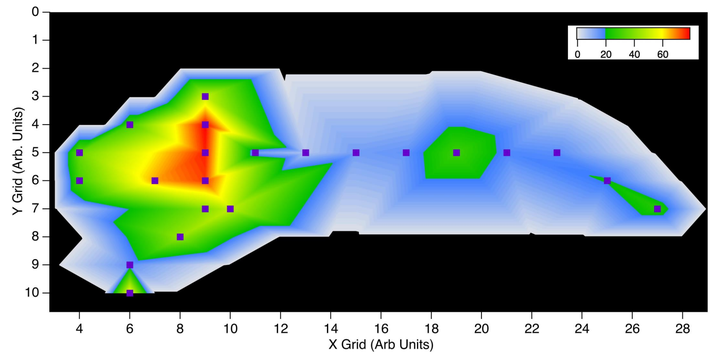

Figure 7. Mapping of Vis reflectance at 600 nm

The blank areas in the UV map are due to a lack of data in those sections, which results in a break in the map.

Conclusions

- Reflectance in areas stripped of some of the outer layers was much higher than layers with the outer layers.
- The areas with lower reflectance on the tusk have shellac present overtop layers of lacquer.
- The higher reflectance of the plaster is due to the rougher surface it provides in comparison to the outer shellac.
- The UV and Vis maps created from the spectra will provide useful information to conservationists interested in how to best preserve the tusk and which techniques to use.
- For future work, a higher spatial resolution would provide a better map, and the mapping done with data collected proves it is possible using this technique.
- More data points could easily be taken of the tusk and used to fill in areas where the points chosen did not give enough information for the map.

Acknowledgements

- The Roy J. Carver Charitable Trust Grand for funding research done on the tusk.
- The University of Northern Iowa
- UNI Museum for providing the tusk for research
- Dr. Sebree
- Shaylah McCool, Carli Russenberger, and Bailey Miller for their additional work on the tusk

References

1. UNI ScholarWorks. https://scholarworks.uni.edu/mastodon/ (accessed Sep 21, 2019).
2. Blitz, J. Diffuse Reflectance Spectroscopy. Modern Techniques in Applied Molecular Spectroscopy Techniques in Analytical Chemistry. Mirabella, F. M., Ed.; John Wiley & Sons, Inc, New York, 1998.