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NIR Mapping of the Mastodon Tusk Layers

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NIR Mapping of the Mastodon Tusk Layers

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Background

This tusk was unearthed in September of 1933 in the town of Hampton, Iowa. About two feet from the proximal end, the tip broke upon extrication. In order to preserve this archaeological finding, many layers of lacquers, plasters, and varnishes were applied.[3] The layers of preservation are not well identified, as well as the timing of application.

By using the Near-Infrared (NIR) technique, infrared light is applied to the tusk and wavelengths are absorbed. The absorbances can help determine the functional groups of the restoration materials in the NIR range of 4,000 to 10,000 wavenumbers.

The objective of the experiment is to provide guidance towards the identification of preservation techniques. By identifying the compounds, a more accurate timeline of preservation application can someday be composed.

Methodology

- Orange netting was purchased, placed around the tusk, and clipped into place on the black base
- A picture was taken of the tusk and ruler guidelines, and an overlay grid was applied
- The yellow dots on the image mark the locations in which data was collected.
- The iS50 NIR module with the SabIR probe was used to collect absorbance corresponding to wavelengths in the NIR region. The probe was held at a 45° angle to the tusk, with the tip of the probe gently touching the tusk. The data was collected.

Image 1 Tusk with grid and data markings

Image 2 **U**sing the SabIR probe on the tusk

Instrumentation

- NIR works by illuminating the substance with broad-wavelength near-infrared light.
- Light is absorbed by the tusk sample. Intensity of the absorbance peaks is relative to the functional groups and color intensity apparent in the molecule.
- Background light intensity is measured before each sample absorbance.
- NIR light vibrates and stretches bonds within the molecule. Absorbance bands are overtones or combinations of fundamental stretching vibrational bands.[5]

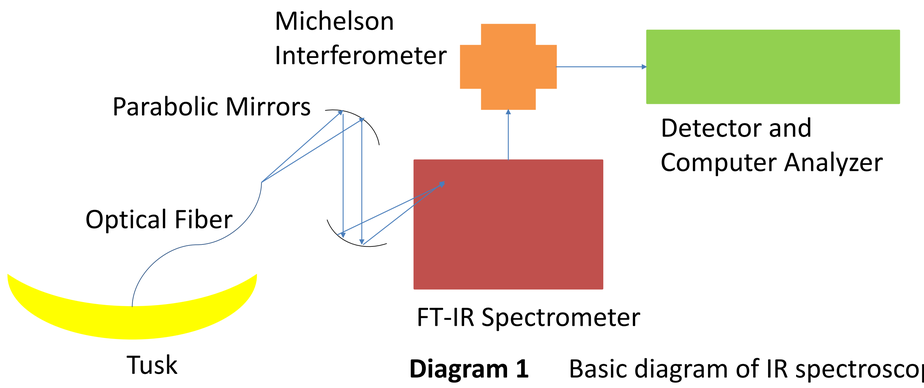
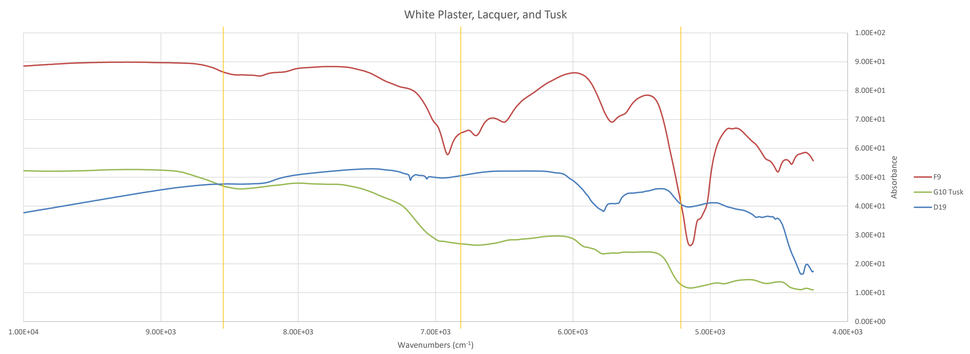
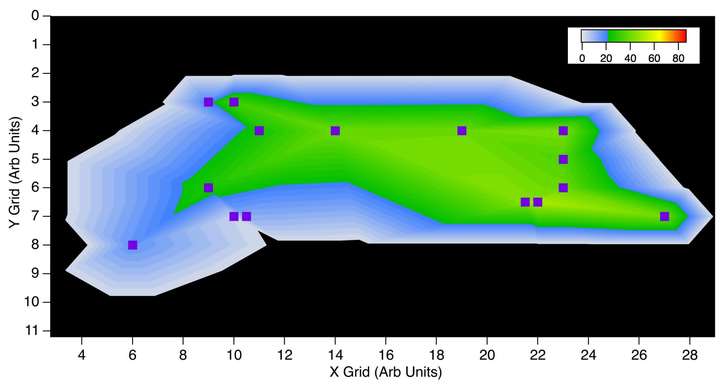


Diagram 1 Basic diagram of IR spectroscopy

Results

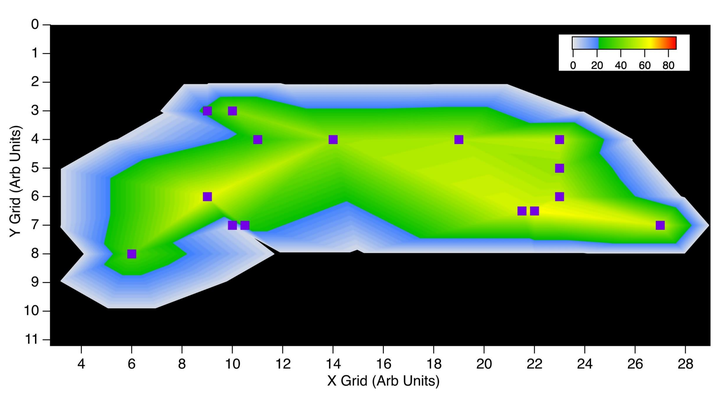


Graph 1 NIR data plots for the white plaster, lacquer, and tusk materials. The orange vertical lines correspond to the wavenumbers of the contour plots below

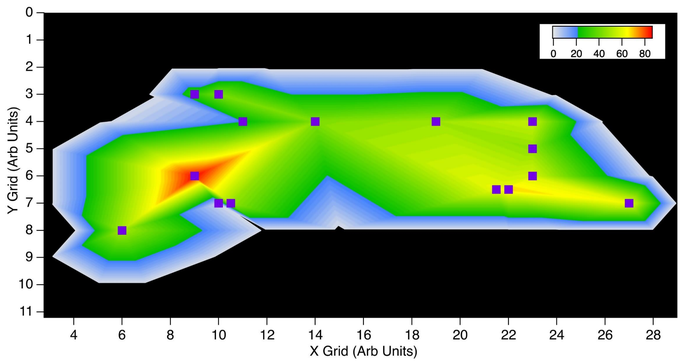


Graph 2 Contour plot at 5200 cm^{-1}. The color scale is in % reflectance

Graph 3 Contour plot at 6800 cm^{-1}



Results



Graph 4 Contour plot at 8500 cm^{-1}

- Overtone and combination bands are likely to be found in the fingerprint region of NIR
- Contour plots are low spatial resolution maps displaying where different chemical structures are located across the tusk

Conclusions

- Functional groups absorb at different wavelengths and the intensity is dependent on molecule concentration
- Low spatial resolution maps display functional group structure intensities across the tusk
- High spatial resolution maps are needed to more accurately determine location of chemical structures across the tusk
- NIR overtone and combination band peak and intensity data can be combined with other techniques to identify chemical structures of preservation materials
- Eventually, a more accurate timeline of application can be identified

Acknowledgements

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