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Energy-Dispersive X-ray (EDX) Mapping of Lead in Mastodon Tusk Using SEM

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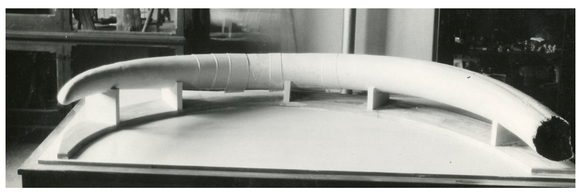
Abstract

The composition and location of lead within a prehistoric mastodon tusk was mapped using Energy Dispersive X-ray (EDX) spectroscopy analysis via a Scanning Electron Microscope (SEM). This analysis was intended to provide information on the distribution of lead throughout the tusk. Data collected from this analysis has provided insights into the sources of the lead.

Background

The restored tusk is a combination of natural tusk and synthetic restoration materials. The tusk was organically found in 1933 in a gravel pit in Hampton, Iowa[1]. The exact soil composition in this area is unknown.

Past restorations on the tusk used a wide variety of plasters, enamel, varnishes, and lead white paint[2]. It is known from previous literature that trace amounts of lead from the environment can naturally make its way into animal teeth through biochemical pathways[3]. It is suspected the same mechanism occurs in Mastodon tusks. The lead can be both localized in specific locations and spread throughout in trace amounts on the tusk. With all of the potential sources of lead taken into account, the composition and location of lead could be mapped using Energy Dispersive X-ray (EDX) spectroscopy analysis via a Scanning Electron Microscope (SEM)[4].

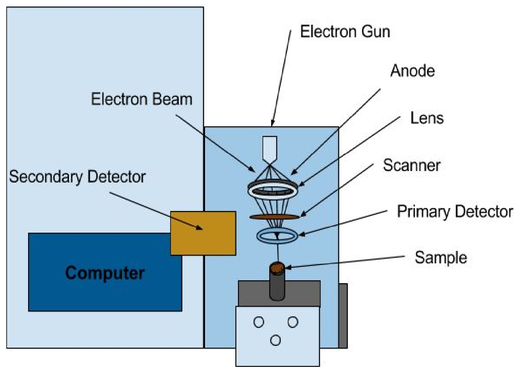


Lead Importance

- Protects the health of the conservators working on the tusk[5]
- Could provide an insight to the diet of the mastodon
- Trace amounts of lead in teeth and tusks could reflect the lead amounts in the prehistoric environment[6]

Objectives

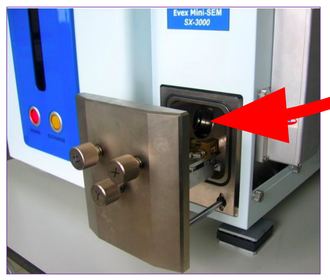
1. Determine the location of the lead in the tusk
2. Determine the concentration of lead throughout the tusk.
3. Propose where the lead came from and whether it will effect restore techniques.

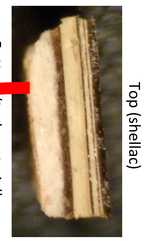


- SEM imaging produces a high resolution image by directing a beam of electrons on to sample
- The electron beam interacts with the atoms of the sample and causes electron displacement, thus X-ray emission patterns
- EDX mapping works by detecting X-rays emitted from the surface of a sample and matching the emission patterns to a known element, creating a map of elements over the surface[7]

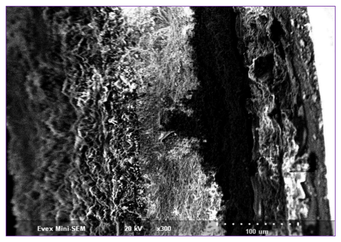
Procedure

- A tusk cross-section sample was positioned on the sample pedestal using carbon tape.
- The sample was loaded in the SEM chamber shown below[8].
- The microscope was focused with magnifications at 300x and 700x.
- EDX analysis was done on the focused SEM images.



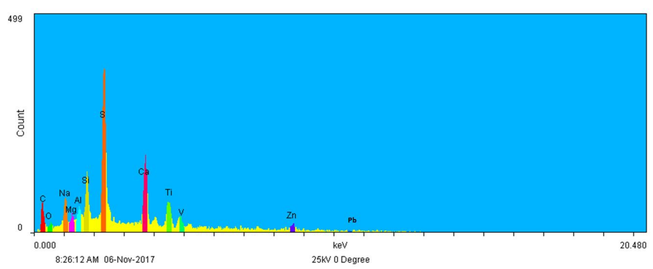


SEM/EDX



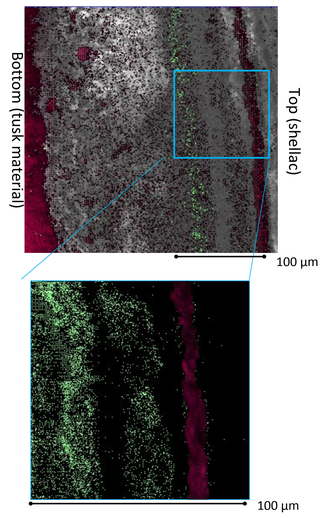
- Allows for a complete snapshot of the overall cross-section
- Allows for a comparison of structural features and the elemental composition

EDX Spectrum



- The EDX spectrum of the tusk cross-section is shown above.
- The peaks are very selective and are with a specific element.
- The background of the EDX shows up as noise on the spectrum.
- The peak of interest is Pb.

Lead Composition Analysis



- Pinpoints what layer the lead is located in[7].
- A Pb (green) vs Ca (red) composition map (pictured to the left) was produced using the 300x SEM image.
- The Pb is localized in one layer of the cross-section.
- Trace amounts can be found in the Ca (actual tusk material).
- Multiple layers of restoration material between the layer with lead and actual tusk material.
- Layer with Pb (Green) zoomed in to 700x.
- Pb is still localized, but trace amounts have leached into other layers.

Conclusion

- There are some highly localized lead concentrations in the tusk. (See Poster by Tray Hickie)
- Significant amount of lead in lead white paint layer, so proper safety precautions should be taken by the conservator. From the 700x image, it appears like there might be at least two layers of lead white paint.
- The lead white paint layer is several layers away from the actual tusk material. So lead detected in tusk is not due to leaching from the lead white paint layer. (See Posters by Emma Shipley and Dmytro Kravchuk)
- A trace amount of lead was observed in the tusk material. This trace lead could be from natural causes. However, the limit of detection for the EDX is high, so trace data is not quantifiable.

Acknowledgements

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- Joshua Sebree, Ph.D. Dept of Chemistry and Biochemistry

Reference

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