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SEM/EDX Chemical Composition Map of Mastodon Tusk

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SEM/EDX Chemical Composition Map of Mastodon Tusk



Juliana Herran

Background

- ✓ The goal of this project was to study one of the rarest objects in the collection of the UNI museum dating to the Aftonian or Yarmouth age (around 120,000 to 200,000 years old).
- ✓ The tusk is 11 feet, 7.5 inches with a circumference at the proximal end of 2 feet, 2 inches.
- ✓ There have been previous attempts of restoration of this tusk but there are not specific procedures on record that specify the materials or methods used during the restoration attempts with sufficient detail.
- ✓ With the support of the Carver Grant awarded to the UNI museum, research teams containing students from the chemistry, geology, history, art and anthropology departments will contribute to the study and preparation for the final restoration of the tusk.
- ✓ The first phase of the project consists in the determination of the materials used in the past restorations attempts. There are a variety of subprojects using different instruments and analytical techniques to achieve this goal.
- ✓ For this part of the project, a chemical map of the tusk was generated using the Evex Mini SEM/EDX.



Layer upon Layer

- ✓ To better understand the restoration history of the tusk, a time line including the information from the UNI museum archives was generated.
- ✓ The descriptions on the color and appearance of some of the materials used were correlated with the EDX and Raman data.

1930 - Unearthed from gravel pit of W. S. Heuermann section 21, 4 miles south of Hampton, Iowa.
- Tusk was varnished and glazed (no list of materials used on record).

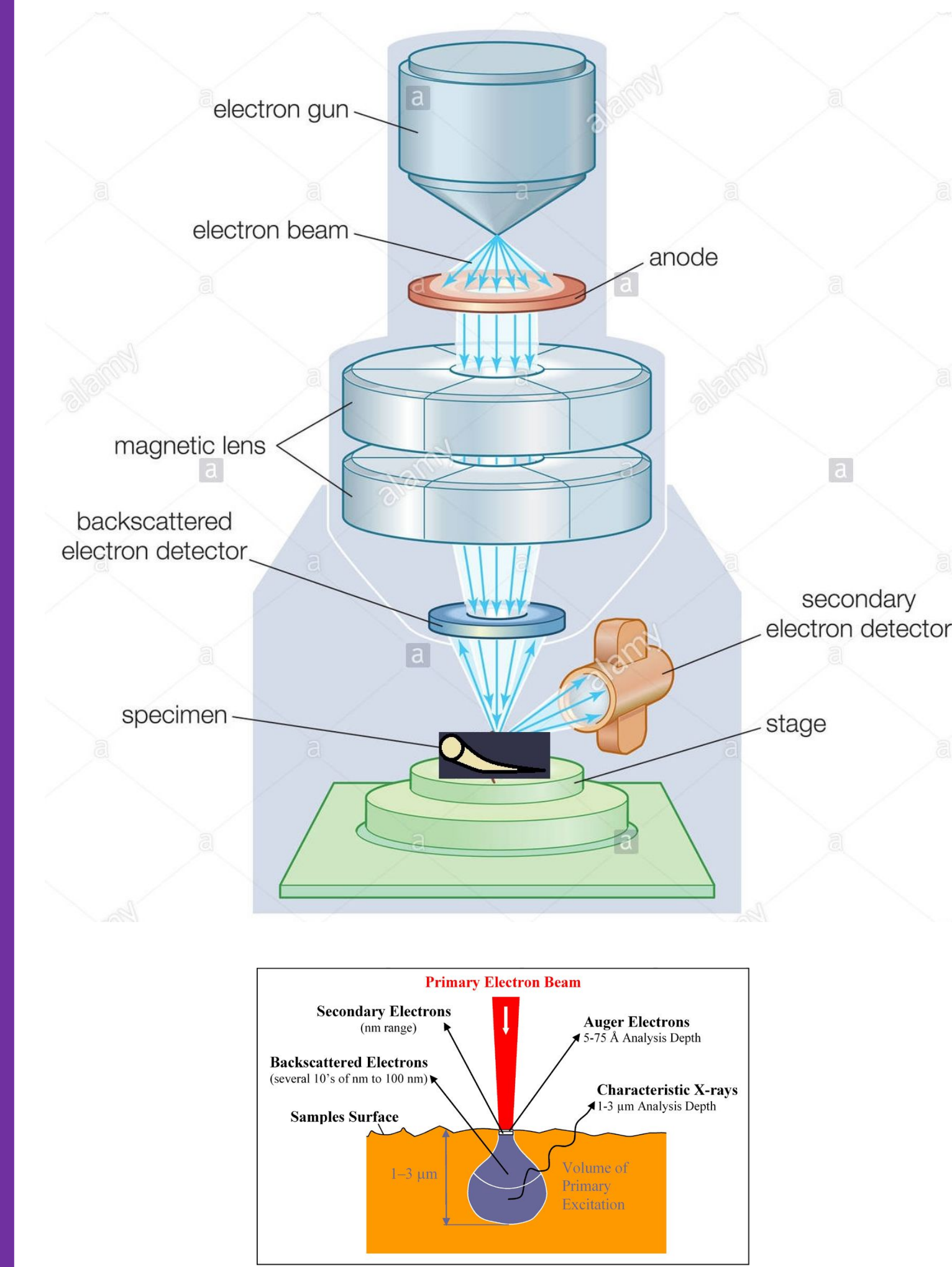
1960 - Tusk was moved downstairs. The glass top and sides were removed.
- Small hairline cracks noted near the tip of the tusk.
- The head of the science department at Price Lab School was consulted and he said that usually during the excavation of a bone it is shellacked several times to harden the bone but this could not be done since it had been varnished before.

1964 - The samples from the tusk used in the present study belong to the pieces that have shipped off the surface of the tusk.
- Each layer down from the top represents a step back in preservation time.

1966 - Tusk was patched wherever it was scaling with a prepared patching plaster.
- Touch up performed with enamel undercoating then glazing liquid (brown material).
- Two coats of varnished were applied on top. Some areas are pulpy and brown from a heavier coat of the glazing compound.

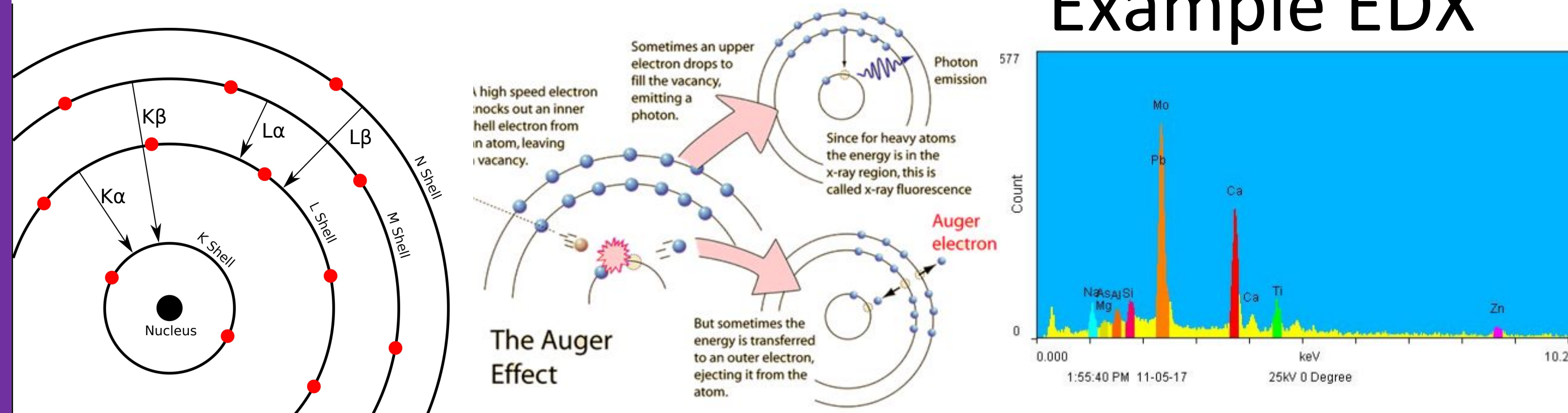
2017 - A wood brace was added near the tip of the tusk to prevent further cracking but the pressure near the tip cracked the tusk much more.
- An unpainted steel band was added near the tip.

Instrumental methods SEM/EDX



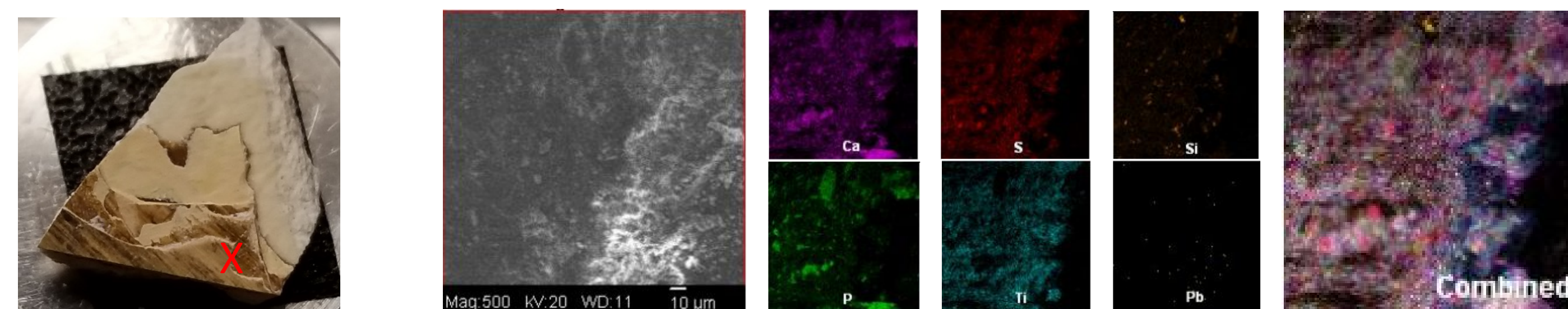
- ✓ **Electron microscope specification:**
- ✓ Magnification 30,000 x (Digital Zoom x 4 ~ 120,000 x).
- ✓ Acceleration Voltage 1 kv ~ 30 kv (variable).
- ✓ Detectors SEI, BEI, EDS.
- ✓ Image Size 4096 x 4096.
- ✓ Voltage 110 volts / 220 volts.
- ✓ **X-ray Detector specifications:**
- ✓ Detector Window SSUTW SUTW UTW Be.
- ✓ Lowest Element Detection Be, B, C, Na.
- ✓ Resolution 128 FWHM @ 5.9kev
- ✓ Sensor Size 10mm, 20mm, 30mm.
- ✓ Cooling Peltier = No Liquid Nitrogen.

Example EDX



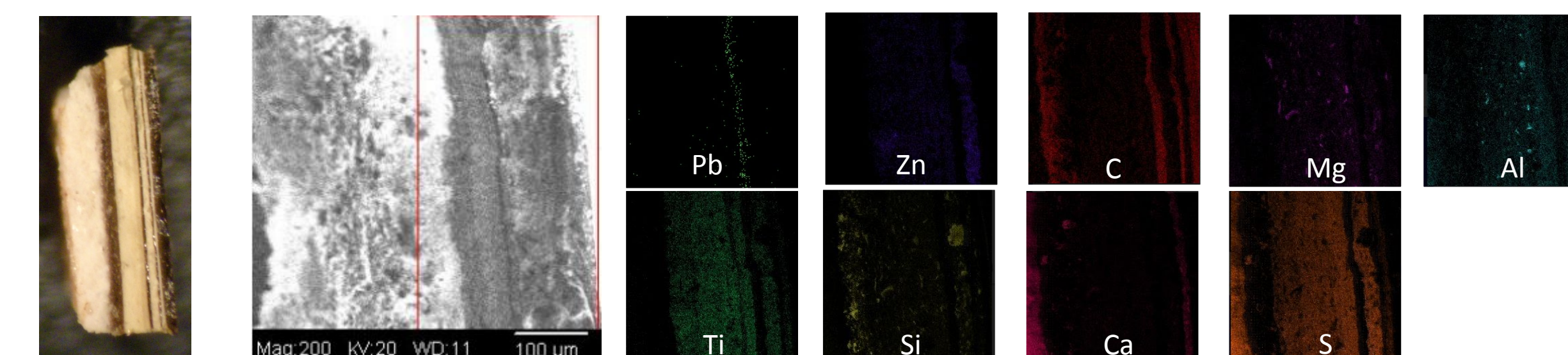
Results

500x Surface Scan



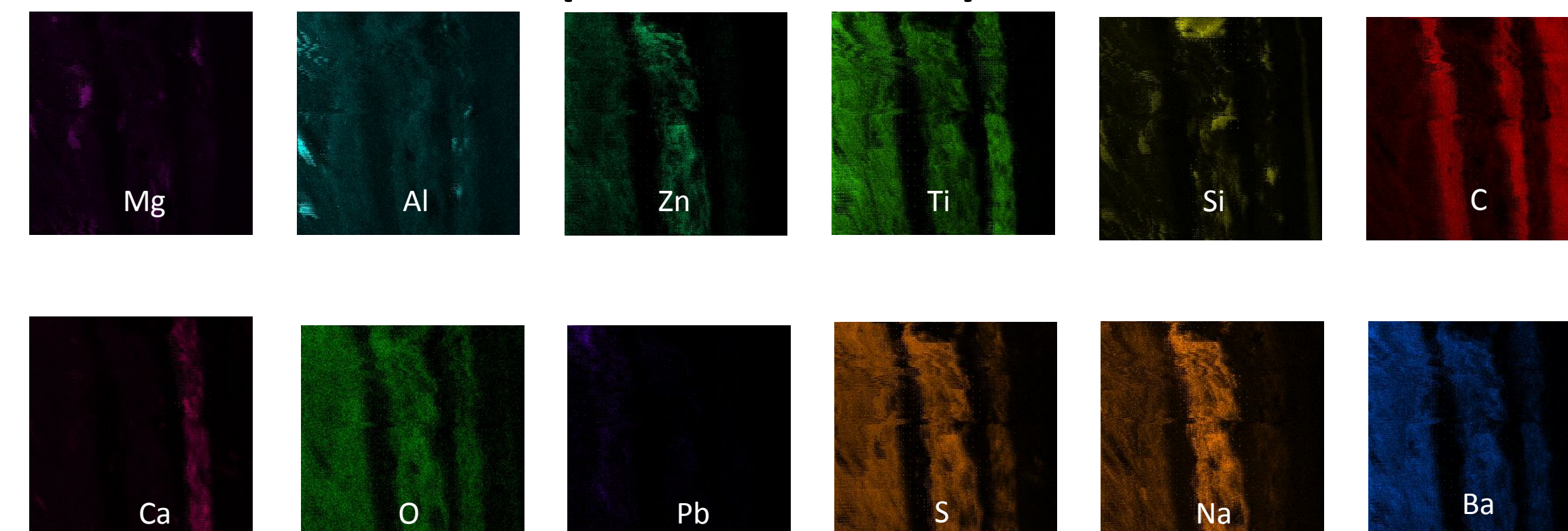
- ✓ This was the first scan taken showing the first two layers of varnish.
- ✓ The EDX results showed very strong Ca and P peaks, strong Ti, S and Si peaks and no significant peaks in the Pb and As regions.

200x Cross-section Scan



- ✓ This map presents the entire cross-section scan including all layers.
- ✓ The EDX results showed a very strong S peak and strong Ca, Si, Ti peaks. Smaller Na, V and Al peaks were also found but there was no significant peaks in the Pb or As regions.

700x Cross-Section (red box above)



Results

- ✓ There were 7 total layers in the analyzed samples corresponding to layers of the different varnishes plus the tusk itself.



Layers 1, 3, 5 & 7

- ✓ Carbon rich, organic lacquers. The dark areas correspond to the inorganic plasters.

All layers

- Ca and S overlap in layer 6.
- Ti in layers 2, 4, & 6.
- S in layers 2, 4 & 6.
- Pb in layer 3.
- Al in all layers, more clusters on layer 2.
- Layers 2, 4 and 6 are likely plaster layers due to the presence of metals.
- Layers 3, 5 and 7 are likely lacquer layers due to the presence of C.

- ✓ The plaster layer containing Ca and S is most likely CaSO_4 also known as plaster of Paris.
- ✓ The lead layer is probably PbCO_3 from plaster of lead carbonate.
- ✓ Si from sand additives in plasters present in all layers.
- ✓ Titanium oxide based white paint present in layers 2, 4 and 6.

Conclusions

- ✓ Some of the most likely present materials used during the restoration processes include plaster of Paris, plaster of lead carbonate, various resins (likely to be part of the emulsions used) and titanium oxide based paint.
- ✓ The separation of the lacquer and plaster layers and the determination of the compounds used during the restoration processes was successful and is consistent with the Raman analysis.

Acknowledgements

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- ✓ Nicholas Bonde (SEM), Katherine Plotzke (SEM), Treasure Divis (Raman) and PhD. Joshua Sebree.

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