Macro X-Ray Fluorescence Scanning
Of a German landscape

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Macro X-ray Fluorescence scanning (MA-XRF) was carried out on a German landscape using a CRONO Bruker system. This poster showcases a comparison of different analytical parameters, discussing their implications on the analytical data and identifying elements present in the paint layers.

PROJECT

The German landscape painting from a private collection is an oil sketch of a larger artwork titled 'Mountain Valley' by Joseph A. Zeller, a German artist born in 1873.

XRF analysis was conducted at **National Museums Scotland science laboratories** to investigate the composition of the paint layers and suggests some pigment identification through the presence of key elements (e.g. Hg for vermillion). The primary objective of the project was to test various combinations of analytical parameters to achieve the optimal results in terms of spectral data and resolution combined with an optimised acquisition time.

X-RAY FLUORESCENCE

Scanning X-ray Fluorescence (MA-XRF) is a widely used technique to study paintings.

This technique is based on the principles of X-ray Fluorescence spectroscopy, where X-rays are used to excite atoms in a material, and the resulting emitted X-rays are analysed to determine the elemental composition.

MA-XRF involves systematically scanning a sample surface to collect X-ray fluorescence data at multiple points. This scanning process provides spatially resolved elemental information, allowing for the creation of elemental maps and detailed analysis of the elemental composition of the sample.

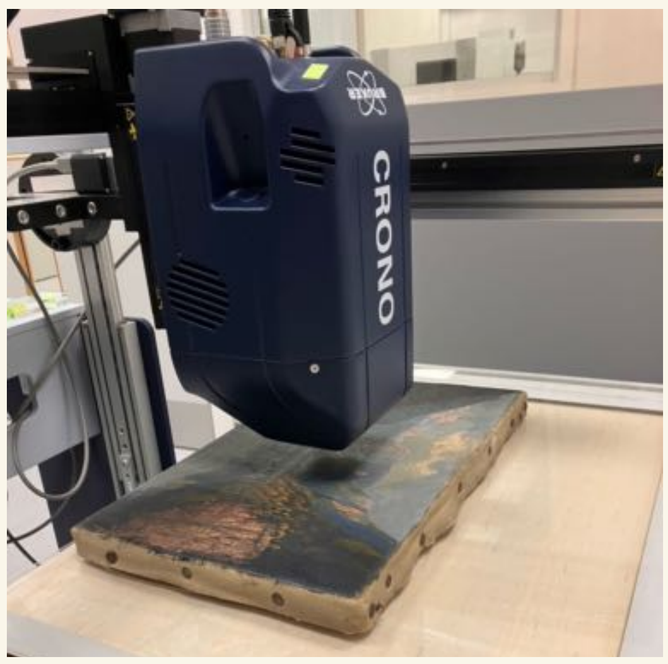
PARAMETERS

Our experiments involved testing the parameters that affect the spatial resolution of a map (collimator and step size). To simplify this evaluation, the voltage and current of the tube were kept constant, at 45kV and 200µA. These parameters allow a wide range of identification of elements.

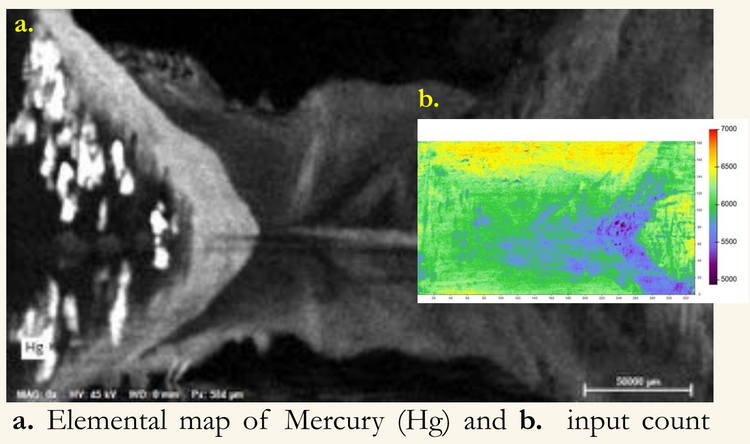
Collimator Size: The diameter of the X-ray beam. **Parameters used:** 2mm, 1mm, 0.5mm

Step Size: The distance between measurement points during MA-XRF, affecting the spatial resolution and coverage of the sample. **Parameters used:** 1mm × 1mm and 0.5mm × 0.5mm.

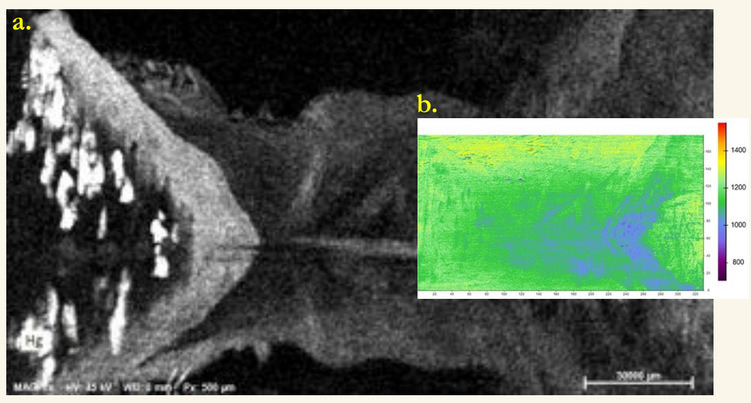
Photography of the German landscape.
Photo credit: Yashasvi Jingar



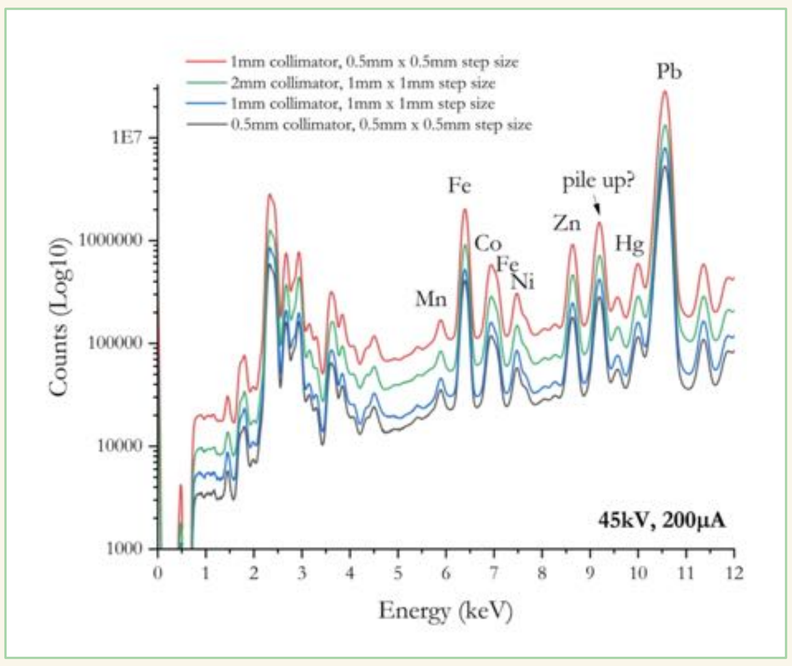
Photography of MA-XRF CRONO system being set up for the analysis of the German landscape.
Photo credit: Yashasvi Jingar



a. Elemental map of Mercury (Hg) and **b.** input count rates using the parameters: 1mm Collimator, 0.5mm × 0.5mm step size, 500µm pixel and approx. 1hr30m acquisition time.
Courtesy of National Museums Scotland



a. Elemental map of Mercury (Hg) and **b.** Input count rates using the parameters: 0.5mm Collimator, 0.5mm × 0.5mm step size, 500µm pixel and approx. 4-hour acquisition time.
Courtesy of National Museums Scotland



Graph depicting the overall input count rates for the analytical parameters considered in the study and displayed in logarithmic scale (log10) with element identification. This represents the overall elemental spectra of the painting.
Graph credit: Lore Troalen, National Museums Scotland.

RESULTS

The combination of a 1mm collimator and 0.5mm × 0.5mm step size yielded the **overall best data (count rates and spatial resolution).** This is probably due to the double sampling of each pixel during the scanning. The best spatial resolution was however achieved with the use of a 0.5mm collimator and 0.5mm × 0.5mm step size, but the count rate was significantly lower, and the analytical time was multiplied by 3 (4 hrs instead of 1.5 hrs). The 2 mm collimator provided the **highest input rates** and the fastest analytical time (approx. 16 mins) but the **lowest spatial resolution.**

CONCLUSION

MA-XRF analysis of the German landscape highlights the significance of parameter selection for optimal results.

The scanning revealed the use of a range of pigment: Lead (Lead white?) used in the background, Cobalt (Cobalt blue?) for the sky, Iron and Mercury (Ochre and Vermillion) in the trees and sky and some antimony-based pigment (Naples Yellow?). To confirm these results and the composition of each paint layer, further analysis would be required on stratigraphic cross-sections.

REFERENCES:

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2. Alberti, R., Frizzi, T., et al. (2017). "*CRONO: a fast and reconfigurable macro-X-ray fluorescence scanner for in-situ investigations of polychrome surfaces. X-Ray Spectrum.*" 46: 297–302.