MA-XRF as a valuable tool in the analysis of paintings

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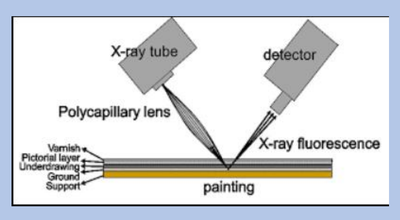
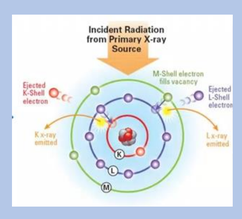
Scanning macro-X-ray fluorescence (MA - XRF) is a well-established technique for examining paintings and provides information about the identity of pigments, painting techniques and the conservation history of the painting. The images of elemental distribution obtained by this method, also allow the visualization of hidden layers of paint, thus providing information about the creative process of the artist and in some cases reveal hidden structures, otherwise invisible.

M6 JETSTREAM

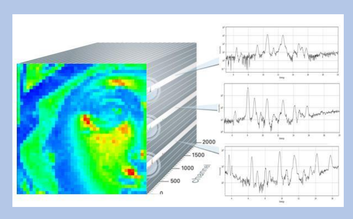
M6 is a state of the art fast (up to 100 mm/s) large area scanner (up to 80 x 60 cm in a single map), it features a polycapillary optic integrated with a 30 watt Rh target X - Ray tube, delivering selectable nominal spot sizes of 100 -580 μm in 100 μm steps.



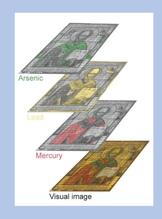
Schematic of the MA-XRF system



X-ray fluorescence



Collection of a spectrum for each pixel



Creation of elemental distribution maps

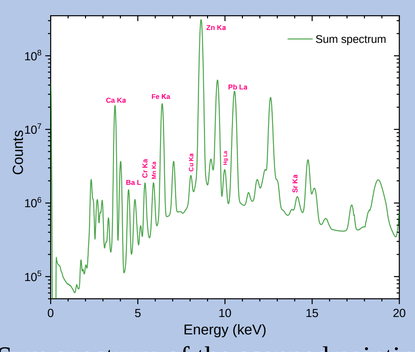
Saint Fanourios
Late 19th century Panel painting

Elemental distribution maps:

- Zinc (Zn) is the main element which is attributed to the extended use of Zinc white. Mercury (Hg) indicates the use of cinnabar and Chromium corresponds to Lead Chromate.
- An underlying painting layer is also detected where Copper (Cu) is the dominant element.

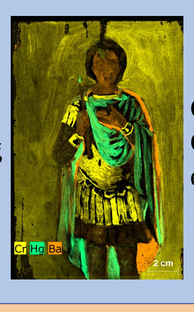
Map information

100 μm beam spot, 100 μm pixel size Total spectra: 2.094.300 50 kV 500 μA Overall time 14:30 hours



Sum spectrum of the scanned painting

Overlap of Fe and Cu elemental maps where the underlying painting layer can be seen.



Correlation of Cr Hg and Ba elemental maps

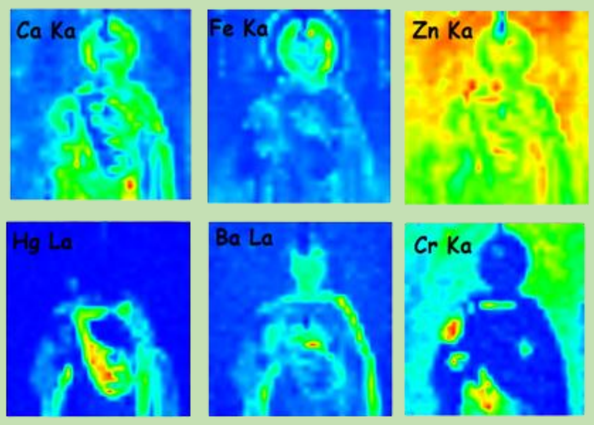
Saints Floros and Lavros
Late 19th century miniature sized icon of Russian origin

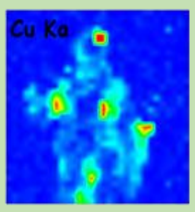
Map information

100 μm beam spot, 200 μm pixel size Total spectra: 206.700 50 kV 600 μA Overall time 1:50 hours

Correlation of Ca, Ba, Cr and Pb elemental maps

TRACER 5i





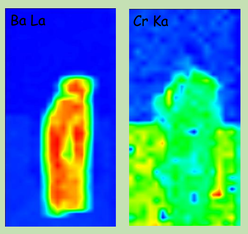
Elemental distribution maps: The spectra were acquired by the developed instrumentation with the use of the 3 mm beam spot, with 3 mm step. The analysis was made with PyMCA (Solé, V.A. et al 2007)

Map information

20 kV 10 μA , 1 s per spectrum Total spectra: 1054
Overall Time: 1.30 hours since on top of the measuring time, 4 s are also needed for the spectrometer's software to register each spectrum

The x-y stage that was built by combining two low-cost linear stages. An ESP 32 controller is used to handle motion. The minimum step that can be achieved is 100 μm on each direction.
Tracer 5i is equipped with a 4-watt Rh target Xray tube with spot sizes of 3 and 8 mm, but we also build one collimator with 1 mm bore hole.

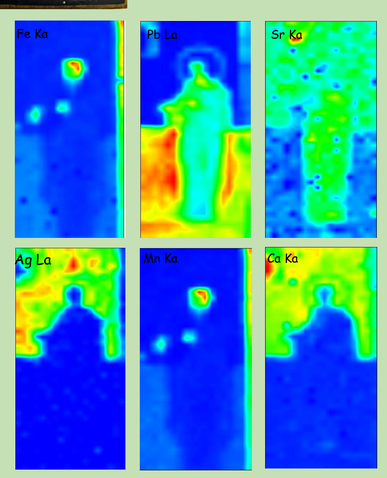
The spectrometer mounted on a tripod during scanning of a panel painting

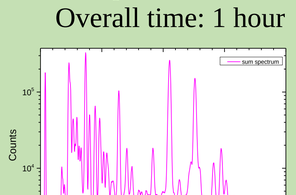


Elemental distribution maps: The spectra were acquired by the developed instrumentation with the use of the 3 mm beam spot, with 2 mm step.

Map information

30 kV 10 μA , 1 s per spectrum Total spectra: 684
Overall time: 1 hour





Sum spectrum of the scanned painting

Conclusions

In the current work, we compare two MA-XRF spectrometers, the M6 Jetstream (Bruker), and an in-house built one that utilizes a handheld spectrometer, Tracer 5i (Bruker).
Although both setups can be used for scanning large areas, the clarity of the images produced from the M6 Jetstream is unparalleled. The setup that utilizes the handheld spectrometer has a lower spatial resolution than the M6 but can be very useful considering the system's mobility.

References

(1) Alfeld, Matthias et al. (2013). A mobile instrument for in situ scanning macro-XRF investigation of historical paintings. Journal of Analytical Atomic Spectrometry. 28. 760-767.

(2) Solé, V.A. et al (2007) A multiplatform code for the analysis of energy-dispersive X- ray fluorescence spectra. Spectrochimica Acta Part B: Atomic Spectroscopy, 62(1), 63–68.

Acknowledgments

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