

Comparison of x-ray absorption and emission techniques for the investigation of paintings

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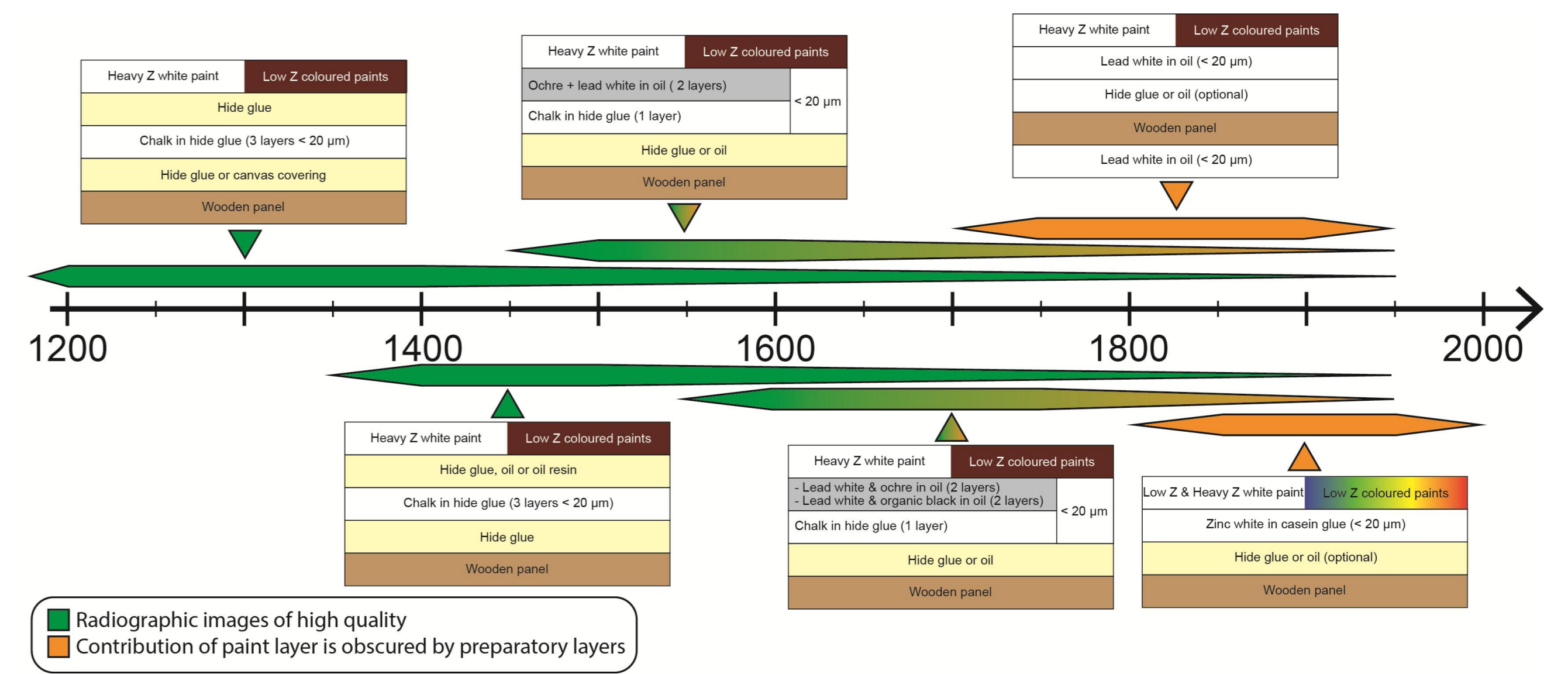
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1. Context & problem

Transmission radiography is an excellent and easy to use method to visualize the internal structure and spatial distribution of heavy Z pigments in the paint layer of 15th – 17th century panel paintings. It is used to examine the creation process of the artist (e.g. changes in composition, underlying paintings, etc.), to identify older restorations and to solve authentication problems. However, some historical paintings have white lead-based preparatory layers. As a result, the pictorial layer can hardly be visualized in the radiographic images. This problem becomes even more important for 19th and 20th century paintings due to the introduction of low-Z white pigments. In this investigation, we explored the possibilities of 4 less common radiographic techniques in order to circumvent the mentioned problems. For this, we applied the techniques on 4 panel paintings with an identical figurative composition made by the artist Peter Eyskens.

2. Technological evolution

The most important stratigraphies used for wooden panel paintings in Western Europe show that more and more lead white was used until 1900 where heavy-Z white paint was replaced by low-Z white paint.

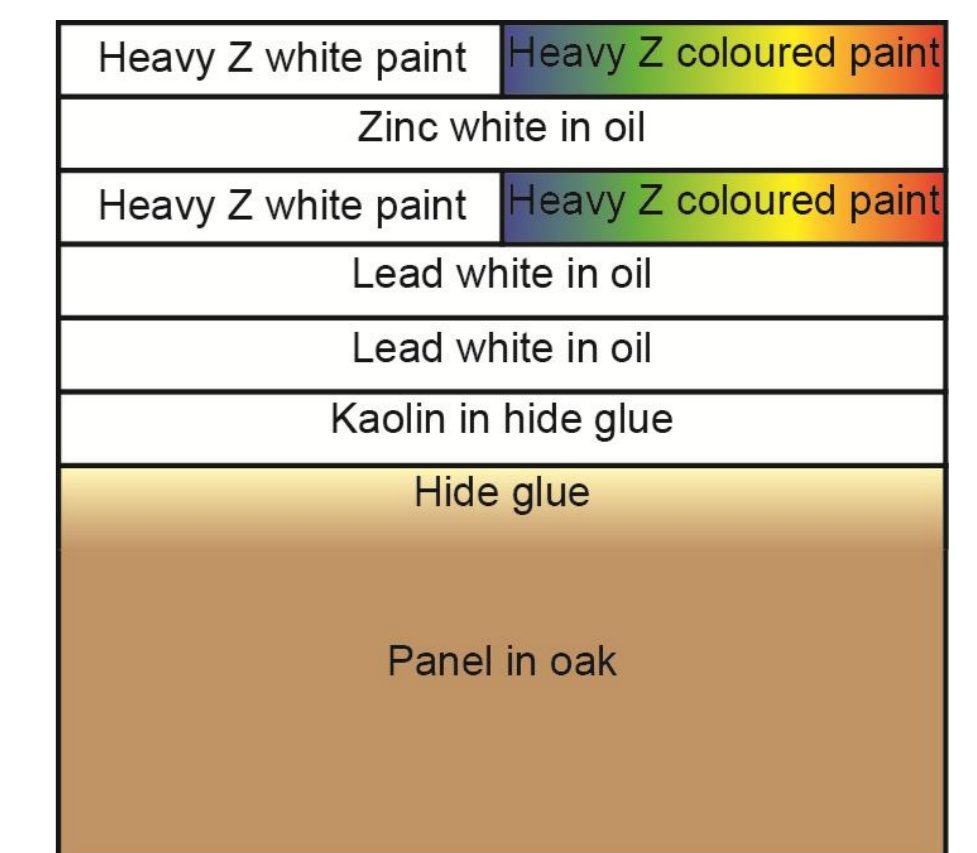
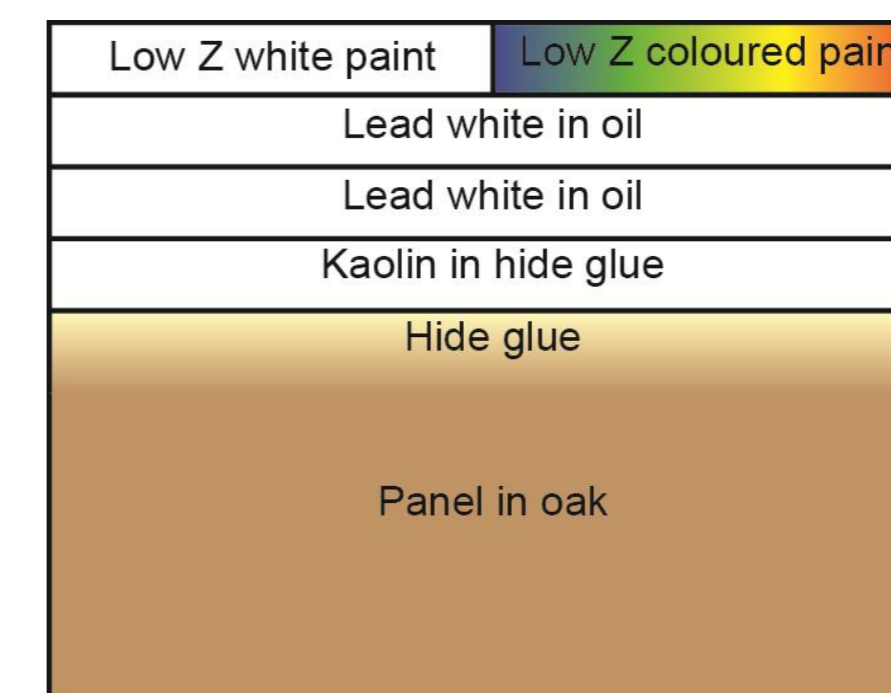
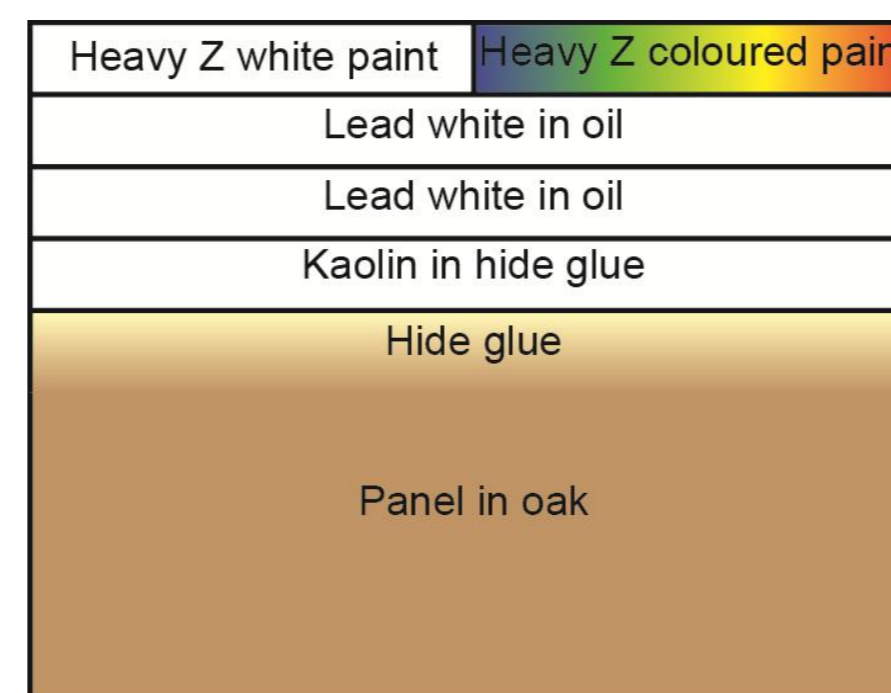
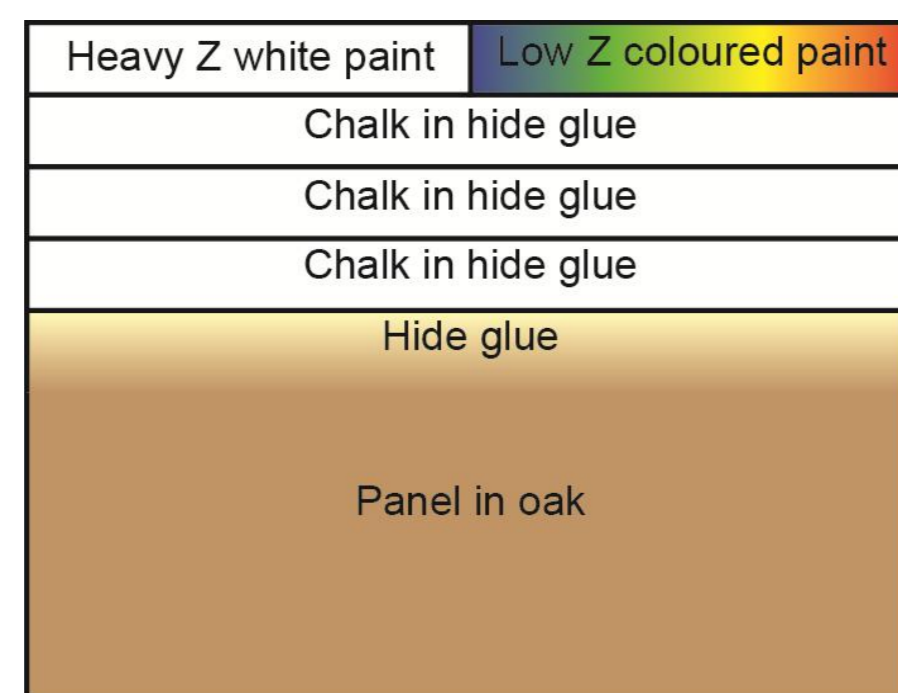
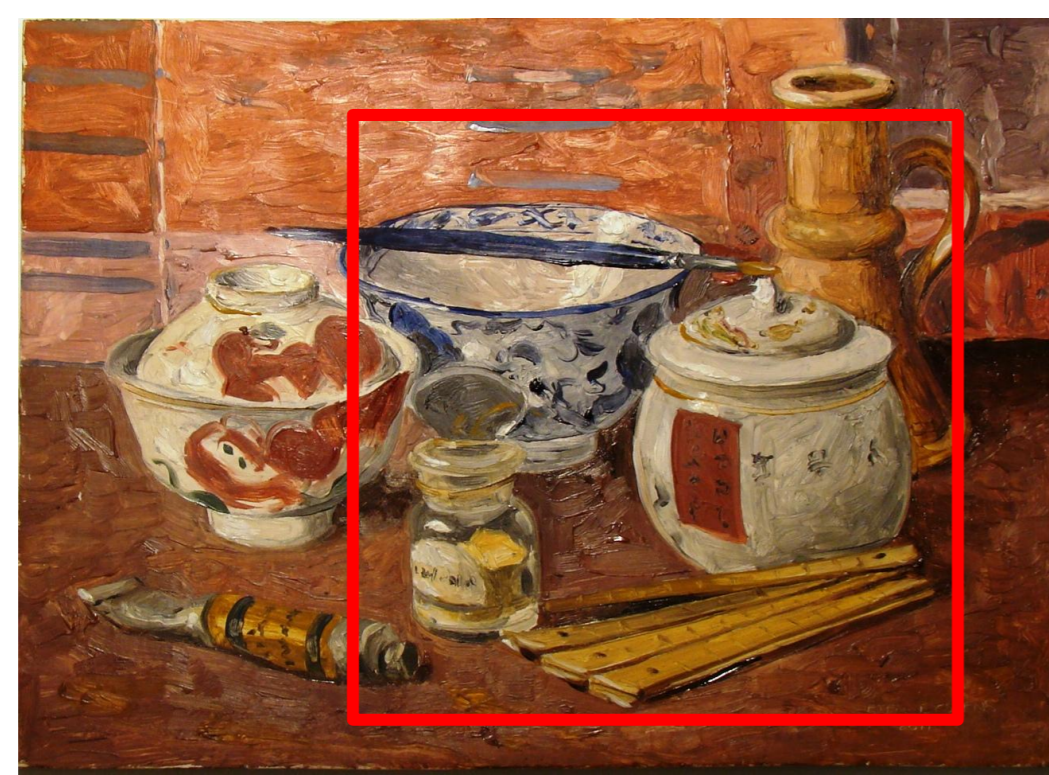


Historical overview of preparatory layers for wooden panel paintings in Western Europe, region north of the Alps.

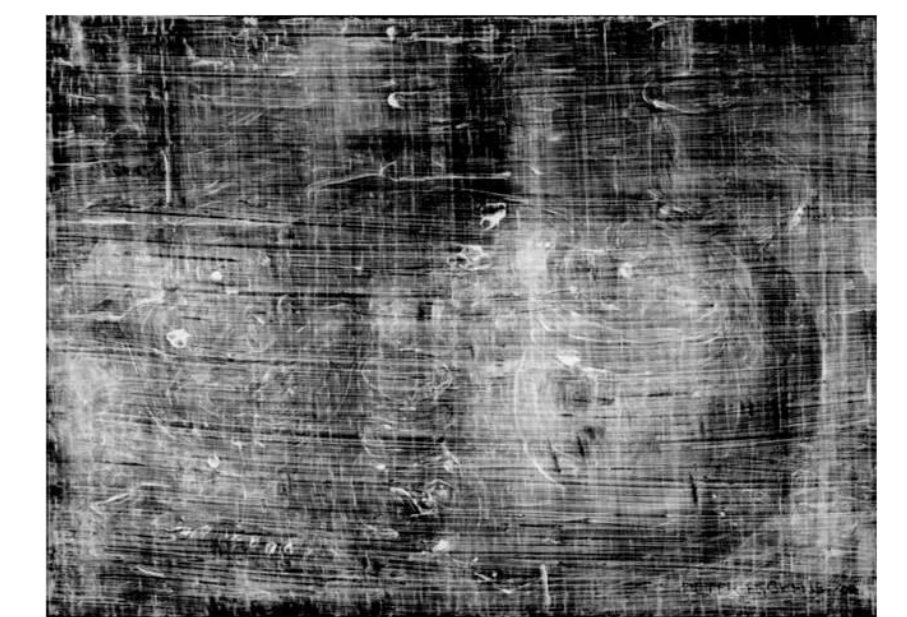
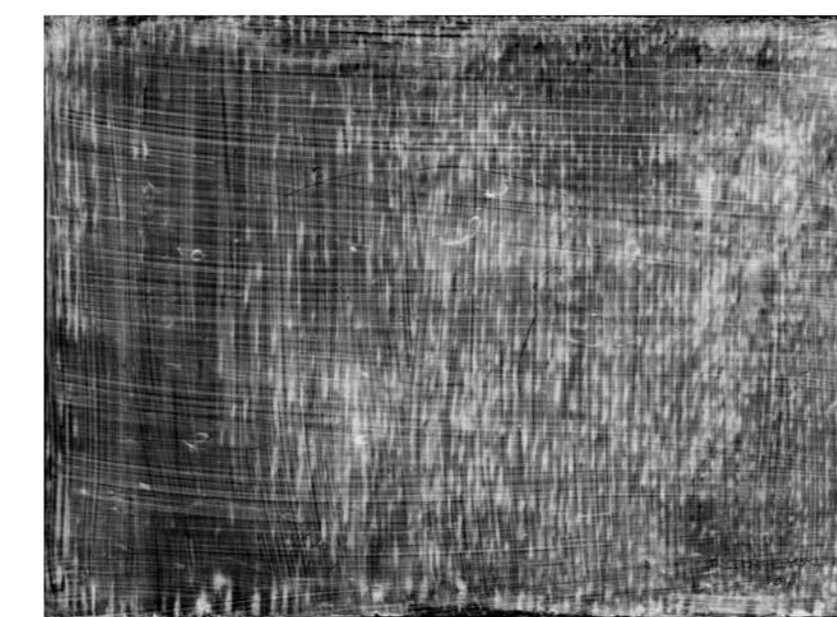
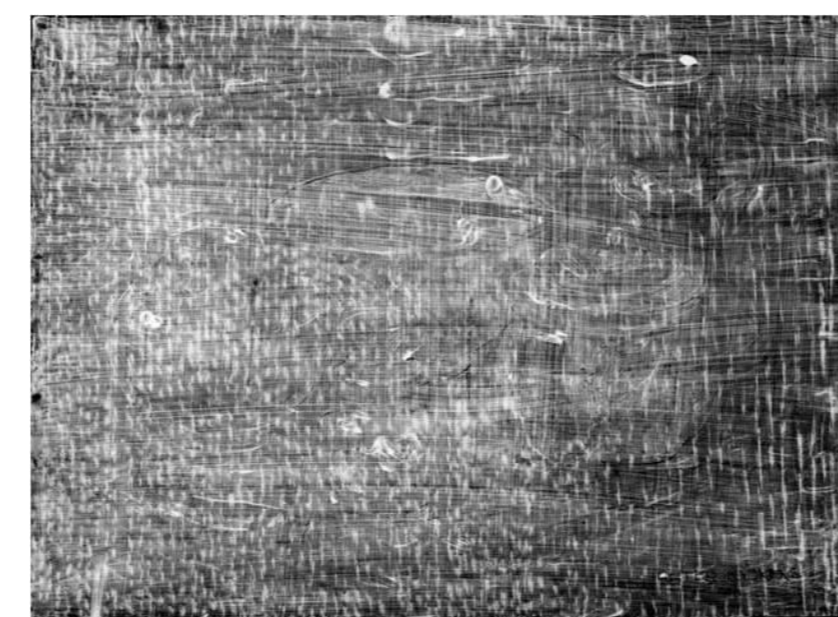
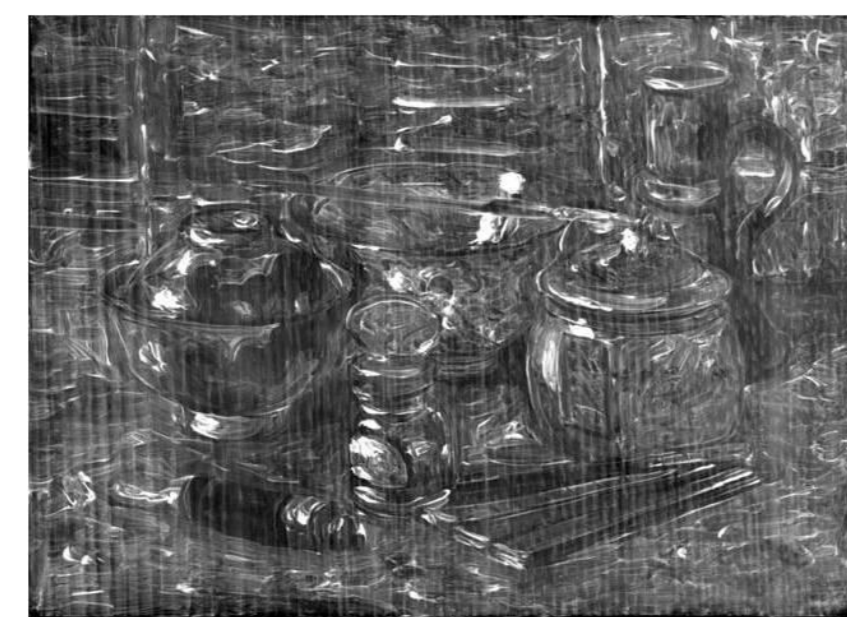
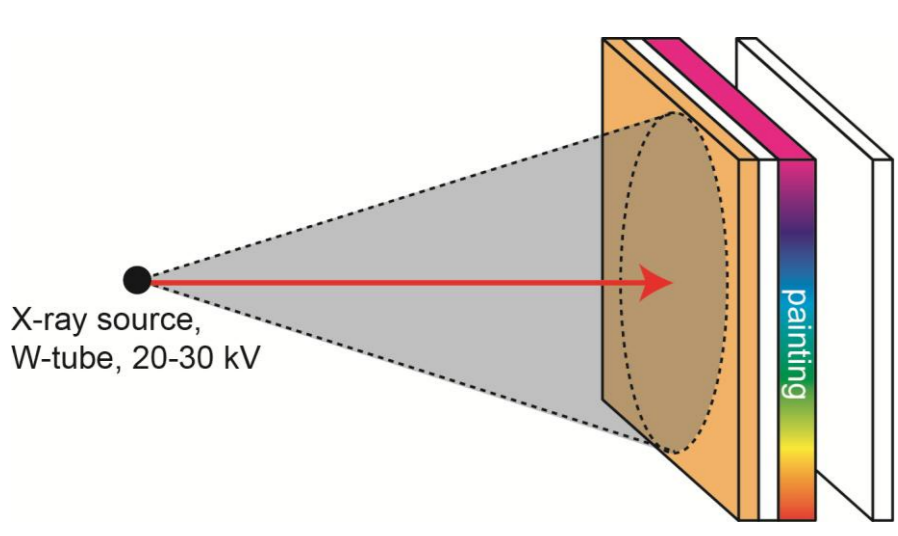
3. Mock up paintings

The artist used a different pigment make-up and a different stratigraphy for each painting. One painting contains an underlying painting. Subsequently, the four paintings are representative for historical paintings with radiography problems.

Photo of the paintings & corresponding cross-sections are shown to the right.

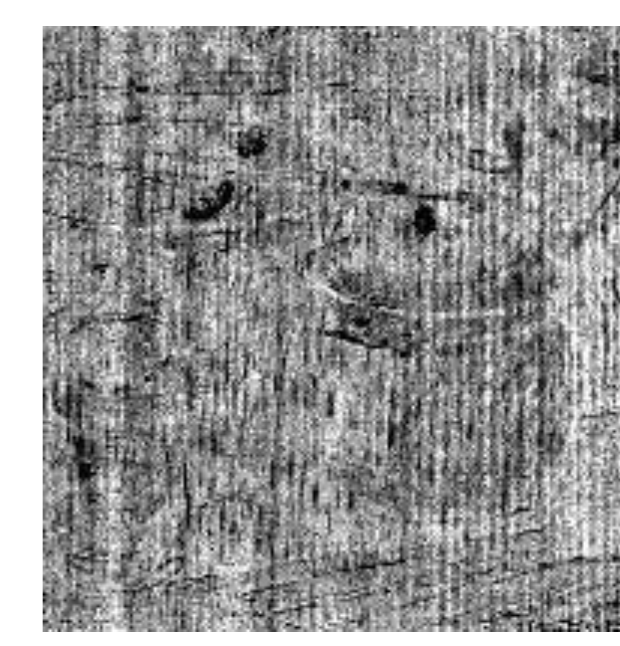
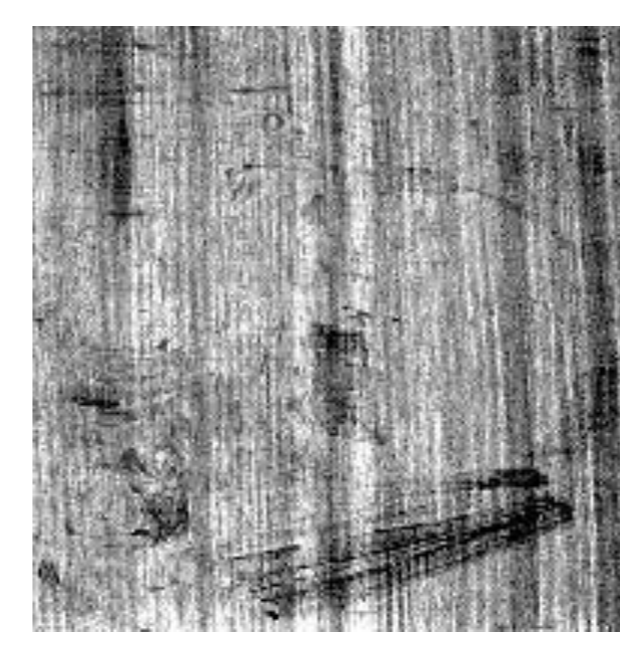
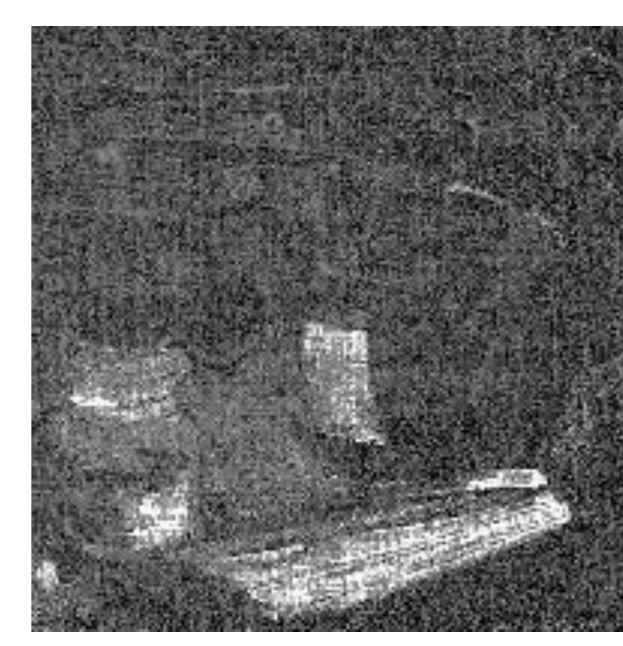
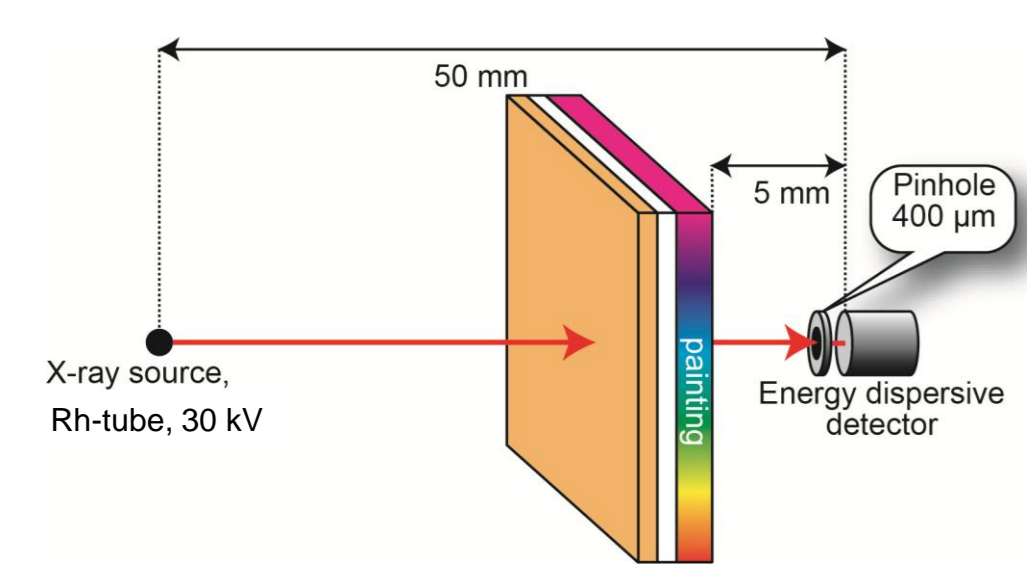


Conventional radiography in transmission mode

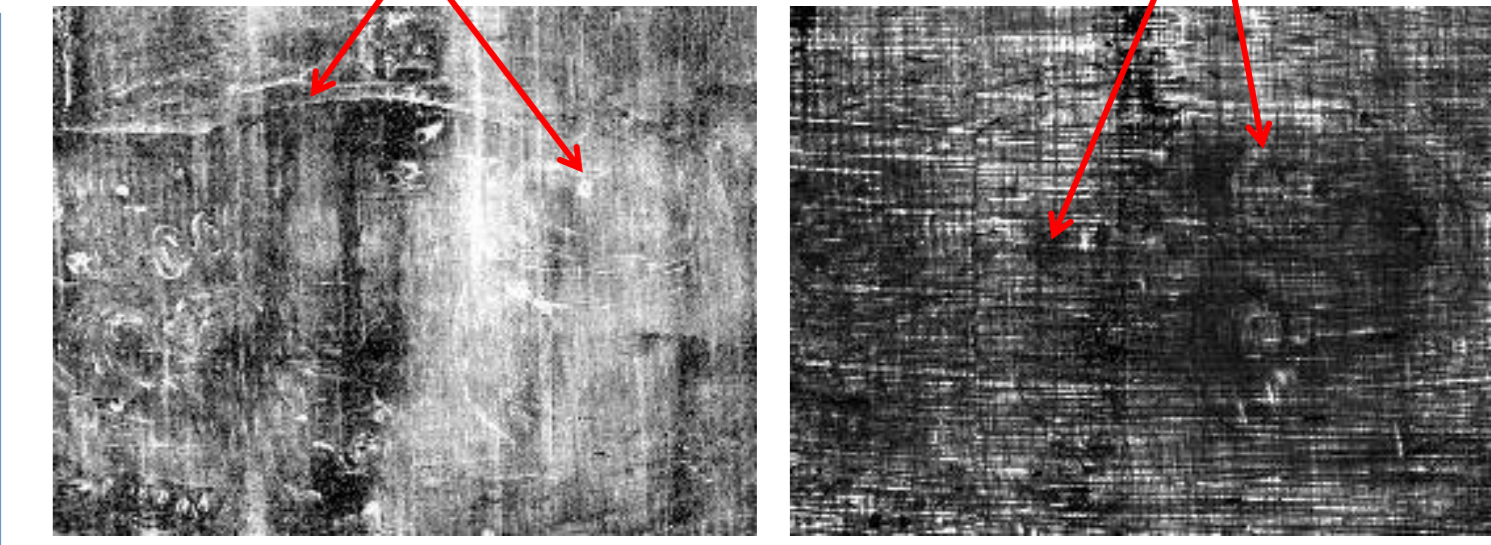


Energy resolved x-ray radiography

Setup: - low power x-ray tube, Rh-anode (30 kV, 20 μ A)
- high energy resolution Si drift detector, Canberra SDD XD 2614 (thickness 500 μ m, resolution 150 eV @ Mn-K α)
- Canberra InSpector 2000, digital signal processor (throughput > 10⁵ cps)
- Newport SMC 100CC-UTS 100CC motorized stages (precision 1 μ m), x and y movement
Measurement time: - 5 sec/pixel, total time > 57 hours



details of the still life painting details of the hidden painting



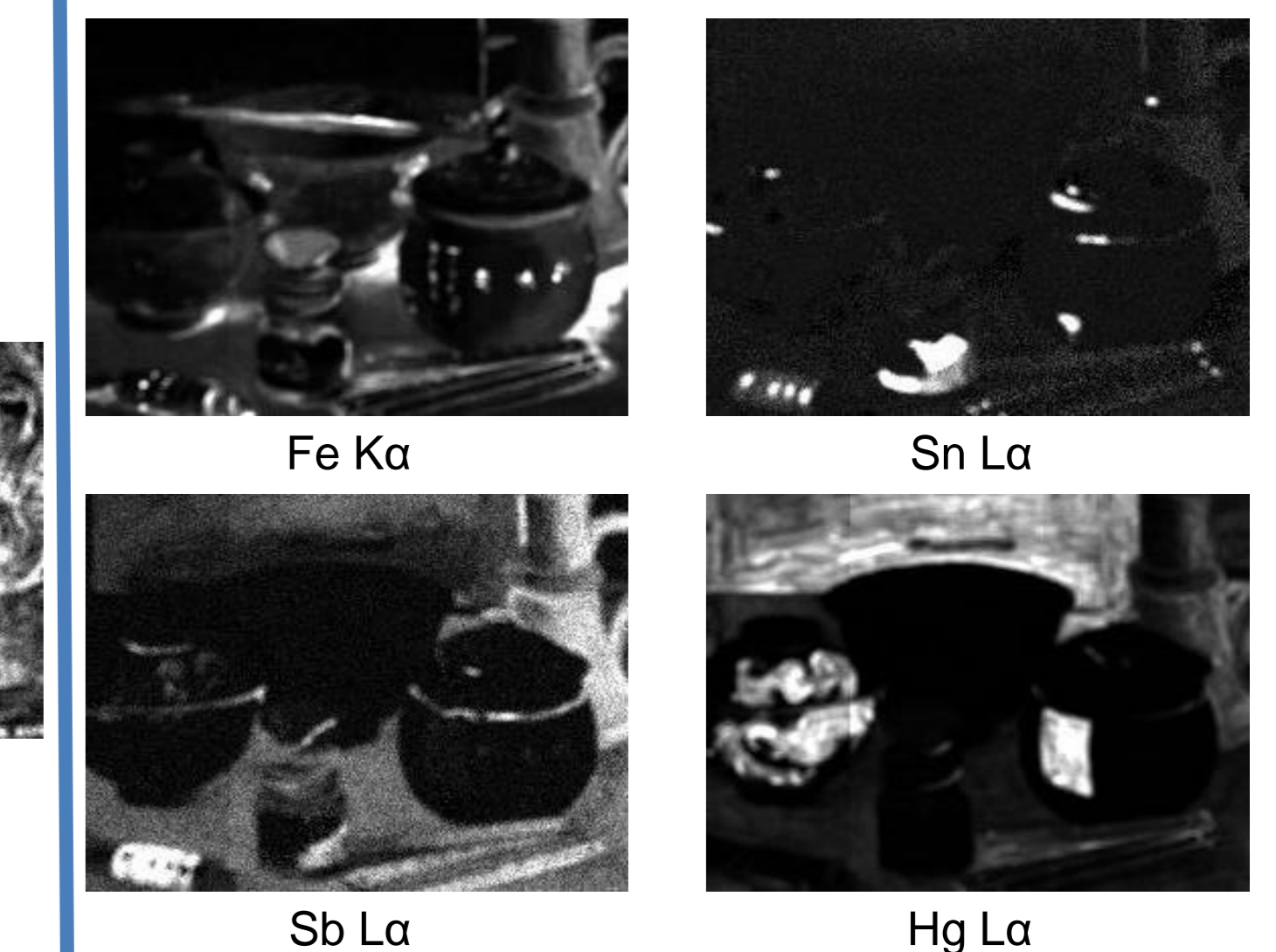
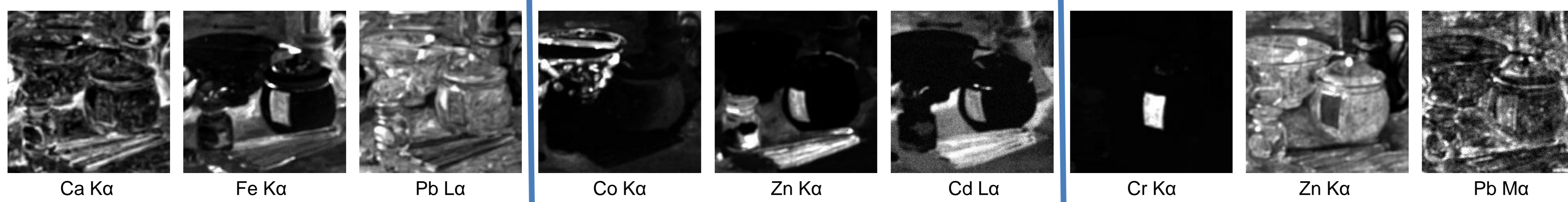
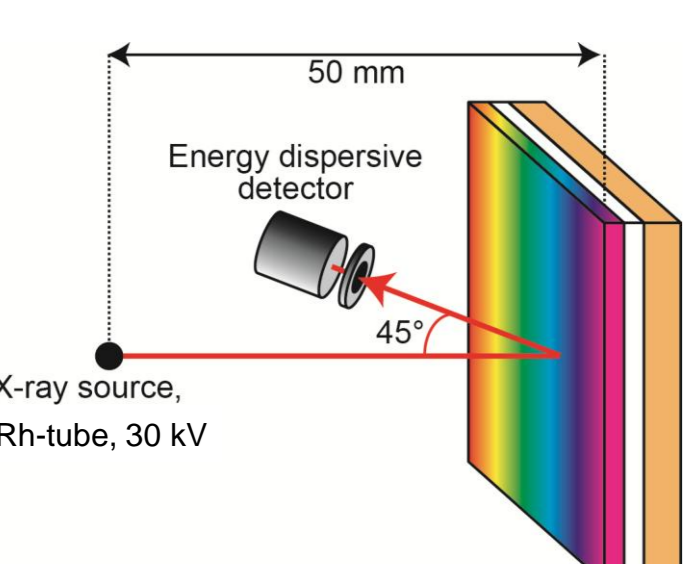
Absorbance difference 12.5 keV – 10.9 keV Zn K edge subtraction image



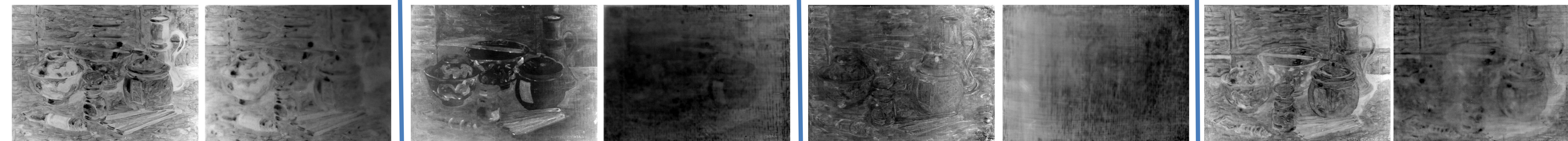
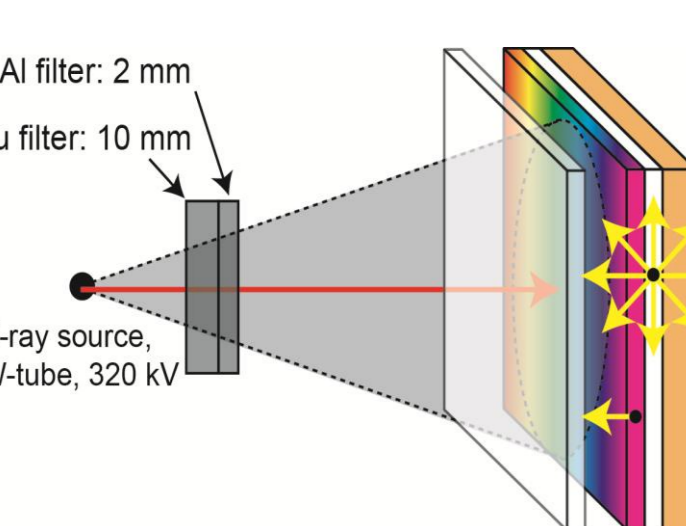
Subtracting two energy-resolved transmission images (20 keV- 13.4 keV, 20 keV-15.4 keV, 20 keV-16 keV) show improved images of the hidden painting (rotate to the left for better recognition)

X-ray fluorescence radiography

Measured simultaneously with energy resolved x-ray radiography in transmission mode
Setup: - high energy resolution Si drift detector, Canberra SDD XD 145 (thickness 500 μ m, resolution 150 eV @ Mn-K α)
Elemental images produced by bAxil software using automatic fitting of hyper spectral cube



X-ray radiography in emission mode



Conclusions

The ability of x-ray based methods to reveal the structure of paintings depends very much on the stratigraphy. The presence of ground layers and type of pigments play an important role. The combination of fluorescence, absorption and emission studies has good potentials.