

THE APPEAR PROJECT AT THE KHM: MULTITECHNOLOGICAL RESEARCH ON THREE MUMMY-PORTRAITS

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INTRODUCTION: In the course of the APPEAR project [1], an international collaboration aiming to promote the study of mummy portraits and to gather scientific and historical findings into a shared database [2] all 10 mummy portraits of the KHM were subject of scientific investigations. The methods applied comprised the identification of the wooden panels (6 sycamore fig, 3 linden, 1 tamarisk) as well as the study of painting techniques and the applied pigments. All 10 portraits were investigated using Multiband Imaging (MBI) and μ -X-Ray Fluorescence analyses (μ XRF). As the KHM runs a macro-XRF (MA-XRF) scanner since 2019 already three of the mummy portraits could be investigated also with this technique. Although the paint stratigraphy of the portraits is expected to be quite simple, unexpected results could be gained and, additionally, the interpretation of the MBI images supported.

WOOD IDENTIFIKATION:

Carried out by Dr. Caroline R. Cartwright, Department of Scientific Research, British Museum
Method: scanning electron microscopy (Hitachi S-3700N)
- backscatter electron (BSE) detector at 15 kV, 3D mode.
- SEM chamber evacuated to 40Pa.
- Magnifications from x35 to x550.
- working distance 12.6 mm to 16.1 mm (preferred 14 mm) with the BSE detector.
- Each sample was fractured manually to show transverse, radial longitudinal and tangential longitudinal sections (TS, RLS and TLS).

MBI:

2 cameras were used:
- A Nikon D80 with a resolution of 10 megapixels and a 23.5-by-15.7 mm sensor dimension,
- and a modified Nikon D3200 with a resolution of 24.2 megapixels with removed ICF/AA filter and a 23.5-by-15.7 mm sensor dimension.
- Both cameras were equipped with a Nikkor AF 28–105 mm, f/3.5–4.5 D lens as well as specific filters for every technique.
- **Images:** Ultraviolet-reflected (UVR), ultraviolet-induced luminescence (UVL), ultraviolet-reflected false colour (UVRFC), visible (VIS), visible-induced infrared luminescence (VIL), reflected near-infrared photography (NIR), and infrared-reflected false colour (IRRFC)

μ XRF:

Instrument: PART II (built within the FWF project no. L430-N19)^{3,4}.
- Vacuum chamber for the detection of low Z elements (Na upwards).
- Tube target material: Pd.
- Polycapillary with a focal spot size of 150 μ m for Cr K_{α} .
- Si drift detector (SDD).
- Operation conditions: 40 kV, 0.4 mA, 100 s.

MA-XRF:

Instrument: CRONO (Bruker)^{5,6}
- Max. scan area: 60 x 45 cm
- Tube target material: Pd
- Collimator: 0,5 mm
- Tube configuration: 50 kV/200 μ A
- Pixel size: 0,5 x 0,5 mm
- Speed: 13,89 mm/s
- Spectra time: 30 ms
- Acquisition channels: 4096

PORTRAIT OF A YOUNG MAN WITH A LAUREL CROWN, 2nd CENTURY AD, TEMPERA TECHNIQUE, TAMARISK WOOD (ANSA_X432):

VIS: - Pink in the background: Blue pigment (ultramarine or indigo, no copper pigment detectable). - Red in the iris and hair: A blue pigment must be present (ultramarine or indigo, no copper pigment detectable). - Yellow/orange in lips, laurel crown tips, parts in face: Probably madder lake (no mineral pigment detectable with XRF). - Clavii: two different appearances (dark parts with Zn are retouches, see MA-XRF).	IRFC: - Pink in the background: Blue pigment (ultramarine or indigo, no copper pigment detectable). - Red in the iris and hair: A blue pigment must be present (ultramarine or indigo, no copper pigment detectable). - Yellow/orange in lips, laurel crown tips, parts in face: Probably madder lake (no mineral pigment detectable with XRF). - Clavii: two different appearances (dark parts with Zn are retouches, see MA-XRF).	UVL: - Yellow: Lip contour, stripe on nose, sclera, garment (appear light pink in VIS); lake pigment (no mineral pigment detectable with XRF) - Pink/red: In lips, stripes on nose, cheeks and chin, laurel crown tips. Final layer of the original clavus. Presumably madder lake. - White line over the right eye and nose: other organic material? No gypsum or chalk, see Ca-map.	Zn Kα: - Retouching using zinc white is clearly visible.	S Kα: - Due to deconvolution, the Pb-M and the S Signal could be separated. The S Signal in the background indicates a gypsum ground layer.	Ca Kα: - Ca in the background indicates once more the gypsum ground layer, eventually penetrating through thin upper layers in the figure.	Fe Kα: The Fe distribution gives evidence for the use of earth pigments: - Brown lines (eyes, nose, separating line in lips). - Some evidence in the incarnate, the hair and the clavii. - no manganese-rich earth pigment (distribution not shown).	Comparison As Kα and Pb Lα: - Due to non-efficient deconvolution Arsen is also visualized in lead white containing regions. - The pure As-signal (red) is visible surrounding the face (orpiment or realgar) - Preparatory drawing?	Comparison of the spectra of the ground layer, the light blue layer and indigo (real Indian) as well as Lapis Lazuli from the pigment database: Both natural pigments of the pigment database show quite similar spectra, differences can be observed in the content of Mn, Fe and Cu, the light elements Al, Si, P are more alike. Nevertheless, in comparison with the spectra of the ground layer and light blue layer of the background the use of both pigments seems possible. Both show a red appearance in IRFC. Therefore, no clear conclusion can be drawn. Indigo seems to be more often used in mummy portraits.

PORTRAIT OF A WOMAN, 117 – 138 AD, ENCAUSTIC TECHNIQUE, LINDEN WOOD (ANSA_X297):

VIS: - Bright parts: Egyptian blue (in incarnate (see Cu-map)) - Bright parts in the garment: Cu is detectable. The VIL signal is not as bright as in the incarnate. The use of Egyptian blue is not clear, eventually some other Cu pigment (Azurite?, see Cu-map) - Also some less bright parts in VIL in the background (wood and white areas) but no distinct Cu signal. Other painting materials may contribute [7].	VIL: - Bright parts: Egyptian blue (in incarnate (see Cu-map)) - Bright parts in the garment: Cu is detectable. The VIL signal is not as bright as in the incarnate. The use of Egyptian blue is not clear, eventually some other Cu pigment (Azurite?, see Cu-map) - Also some less bright parts in VIL in the background (wood and white areas) but no distinct Cu signal. Other painting materials may contribute [7].	Cu Kα: - Most parts coincide with the VIL image. - Additional parts: Pearls of earrings (first version) and area above right eye; other copper pigments. - Background: Probably noise (no reflection of defects in the distribution)	IRFC: - White parts: White pearls of earrings, eye balls; lead white (XRF) - Yellow parts: Mouth, eye lids, cheeks?; minium (see Pb-map) - Green: madder lake (see UVL) and (modern?) organic layer. - Blue band in garment is not clear: black-blueish in IRFC - Pinkish red: wood
UVL: - Red: Garment; madder lake: - Blueish: Pearls of earring and eye balls; lead white - Light bright blue layer: Modern organic coating.	Pb Lα: - A lead white ground layer is present only in the middle part of the portrait. - Lead white is used in the different paint layers.	Zn Kα: Zn can be detected to the left and right of the lead white ground layer (which lies on top and absorbs the Zn signal). Therefore, Zn can be correlated with the wood: - Special treatment? - Provenance?	Fe Kα: Earth pigments: Mostly in the collier (ochre), the earrings (golden parts – ochre - and green stone – green earth) and the eyes (brown). Earth pigments are also used for darker shades in the incarnate. Little iron can be detected in the hair, the dress, the incarnate and the background.

PORTRAIT OF A WOMAN, 161 – 192 AD, ENCAUSTIC TECHNIQUE, LINDEN / SYCAMORE FIG (ANSA_X301):

VIS: - Some parts in the incarnate were coarsely spared. - The blue background was applied with very coarse brushstrokes. - Lead white is also present in the shadings of the garment. - The thin necklace was probably spared, the broad one painted on top of the incarnate.	Pb Lα: - Some parts in the incarnate were coarsely spared. - The blue background was applied with very coarse brushstrokes. - Lead white is also present in the shadings of the garment. - The thin necklace was probably spared, the broad one painted on top of the incarnate.	Pb Mα: - The white layer beneath the blue background also contains lead white, leading to a more homogeneous appearance of lead in the background.	Fe Kα: Earth pigments: - Mostly in the collier (ochre brown and green) and the eyes (brown). - It is also used in dark shadings in the incarnate, in the hair and in the eye brows.	UVF: - Madder lake: red. - The pattern of the border was painted on top of the lead white layer (see Pb M α Map)
VIL: The general observable luminescence is quite low. No Egyptian blue can be detected with VIL.	Cu Kα: Nevertheless, a very little Cu signal is detectable commonly. It seems to be present in the lead white ground layer.	Red: input countrate Spectrum Green: indicated area - A little copper signal can be clearly detected - Reddish parts in IRFC where the white background shines through indicate an addition of a blue pigment.	IRFC: - No copper pigment is present in the upper layers	

Further investigations are needed to identify the copper pigment as well as the grey/blue pigment in the background.

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