Advanced Investigation of the Book of the Dead of Kha at the Museo Egizio of Turin: A MOLAB E-RIHS in-situ study

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Introduction

In February 2024, a comprehensive MOLAB E-RIHS study was conducted at the Museo Egizio of Turin to investigate the painting materials, techniques, and conservation state of the "Book of the Dead" papyrus of Kha (Suppl. 8438), a remarkably well-preserved funerary papyrus from the 18th Dynasty. The study employed a multi-analytical approach, integrating advanced portable and non-invasive imaging and single-point techniques, including scanning Macro X-ray Fluorescence (MAXRF), UV-IR imaging, VIS-NIR hyperspectral imaging (HSI), high-resolution digital microscopy, mapping X-ray Diffraction (MAXRD), Raman spectroscopy, micro-SORS, VIS-NIR and IR external reflection spectroscopy.

Despite numerous studies and analytical projects conducted on the artifact, a comprehensive investigation has yet to be completed. This study, essential for deepening our understanding of both the artifact's history and the written text, will be crucial in shedding light on scribal practices in ancient Egypt, which remain poorly understood. Indeed, papyrology increasingly contributes to defining the "biography of objects"—an approach that, starting from the materiality of artifacts, enables the reconstruction of contexts and histories. Imaging and scanning analytical methods allowed for a depiction of the pigment palette and artistic techniques, highlighting key areas for further investigation using single-point methods.

Papyrus Materials and Painting Technique

Visible image

IRR 950 nm

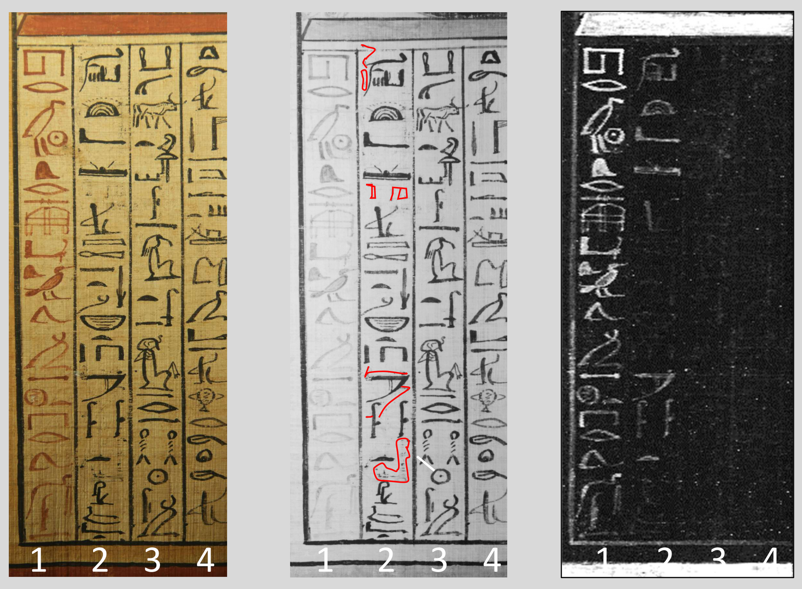
The 14-meter-long papyrus was discovered in the tomb of the royal architect Kha and dates back to the New Kingdom, between 1425 and 1353 BCE. It was unearthed by Ernesto Schiaparelli in 1906 as part of the Italian Archaeological Mission and has since proven to be in excellent condition.

The initial scene depicts Osiris in his customary form as a mummy from the chest down. However, drawings of a feather-shaped decorative pattern in carbon black beneath the white surface are visible: the god's body was originally adorned with feathers, a symbol of protection and rebirth. The reason why these feathers were subsequently concealed beneath a layer of white remains uncertain. It is highly plausible that this alteration reflects a change in aesthetic preference, potentially associated with revisions made during the reuse of papyrus for Kha. Variations can also be observed in the original placement of Kha's belt and the outer feather at the crown of Osiris. Additionally, structural modifications in the construction of the legs are noticeable in the figures of Kha and Merit (IRR 950 nm).

Text columns without (left) and with name (right)

The papyrus was produced in a pre-made format, meaning that no name was originally inserted. Typically, the name appears after chapter titles, or is found at the end of chapters. Kha's name was added only later and not consistently. This later insertion is particularly evident in the second column, where the originally inserted name was soon recognized as incorrect. It was subsequently erased, and another scribe later wrote the name of Kha; in fact, it is spaced very widely, as the scribe had to fill all the empty space.

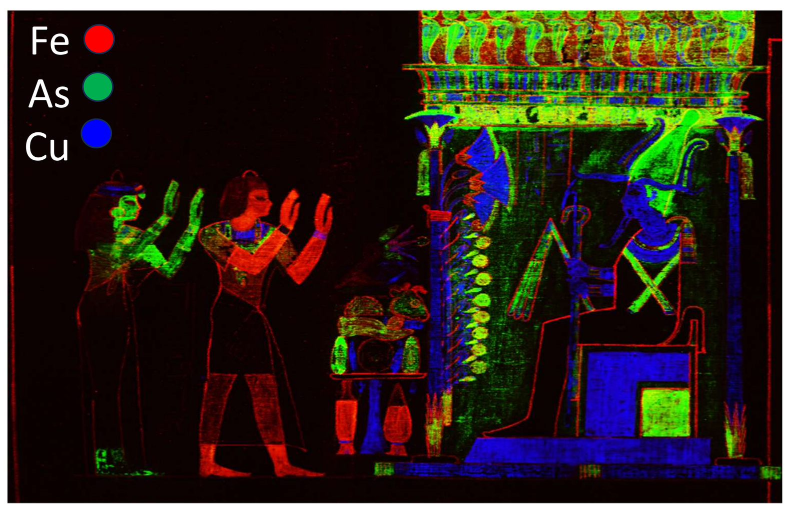
Visible image | **IRR 950 nm** | **MAXRF Fe-Kα**



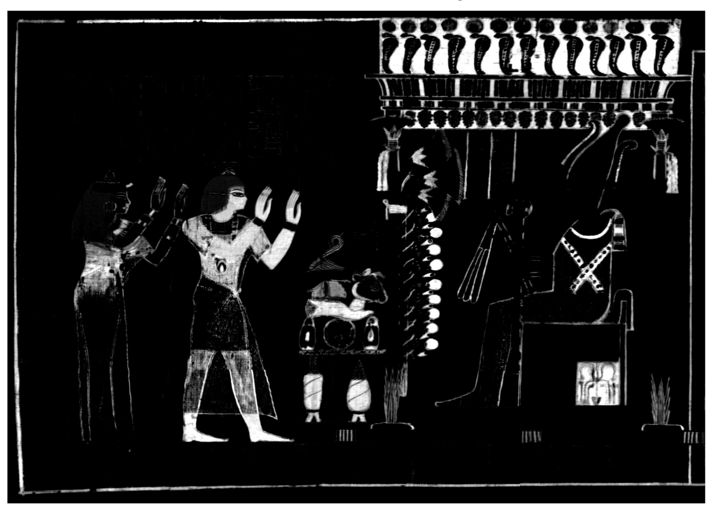
MAXRF reveals the presence of iron in the first column (red ink), confirming the use of red ochre, as is commonly found in red inks of this period. Iron is also detected in the second column, where the writing appears in black. It is likely that this column originally featured a form of address written in iron-based red ink, which was later erased. When the papyrus was reused for Kha, a carbon-based black ink was applied over the partially preserved red text. High-resolution digital microscopy images clearly show traces of red ink beneath the black ink layer.

High-resolution digital microscopy

MAXRF

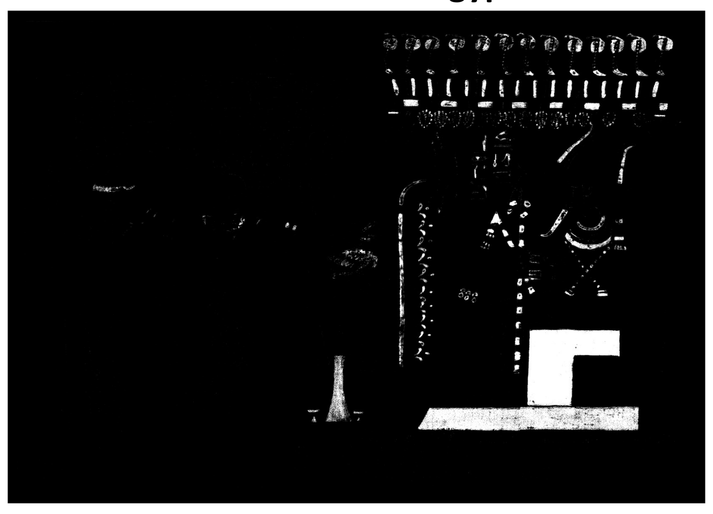


VIS-HSI Distribution map of Fe-oxides



VIL – distribution of Egyptian blue

VIS-HSI – distribution of Egyptian blue

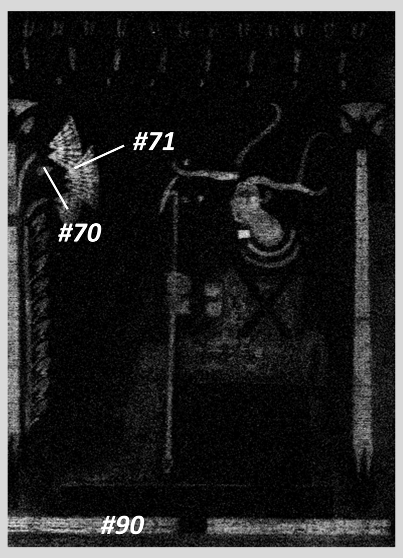


MAXRF distribution maps of iron, arsenic, and copper provide key insights into the palette used for the papyrus. Iron is attributed to iron oxides, consistent with hematite—the main component of red ochre—as confirmed by VIS-HSI imaging. Copper is associated with copper-based blue and green pigments, and both VIL and VIS-HSI maps clearly indicate that the blue tones were achieved using Egyptian Blue. Notably, traces of this pigment are also visible on the face and hands of Osiris, as evidenced by VIL imaging and high-resolution digital microscopy. From the 18th Dynasty onward, however, too few Book of the Dead papyri have been documented to confirm or deny the use of blue for rendering skin tones. Arsenic is found in both the red and yellow areas; analyses reveal a complex mixture of arsenic-based compounds, as detailed below through MAXRD and Raman spectroscopy.

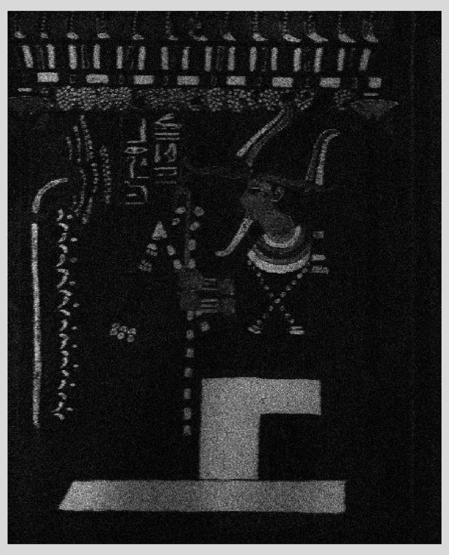
VIS-HSI – distribution of Cu-based green pigments

Visible image

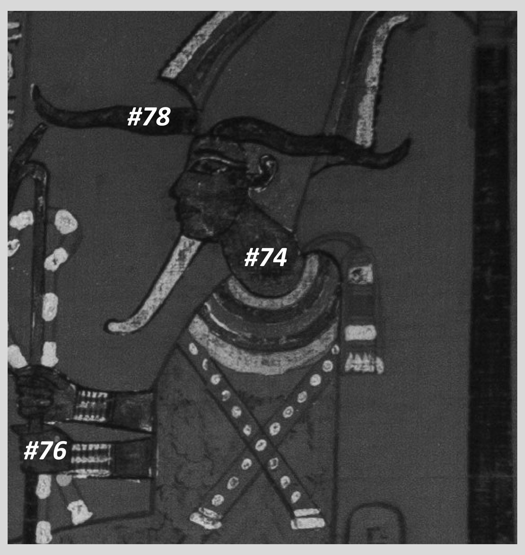
MAXRF Cl-Kα

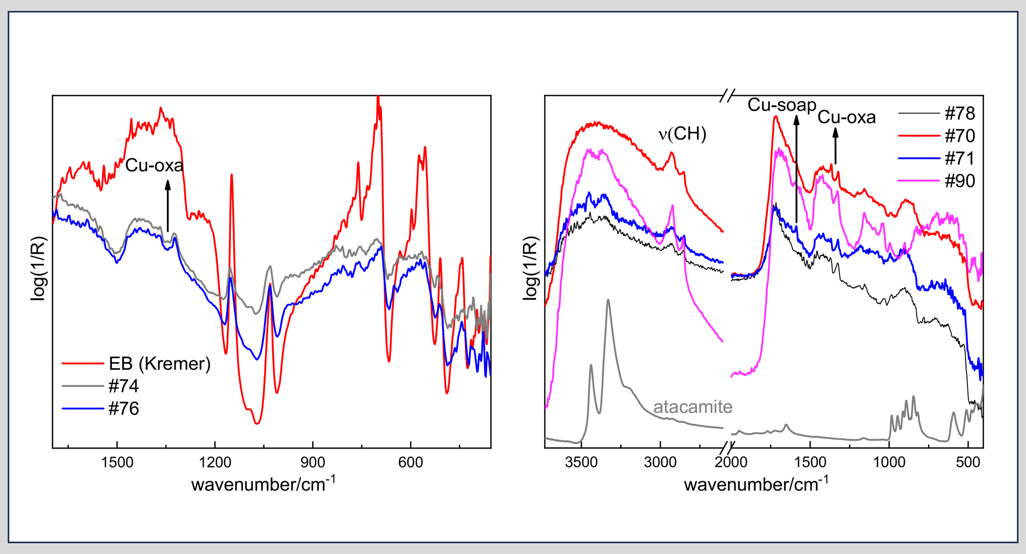


MAXRF Si-Kα



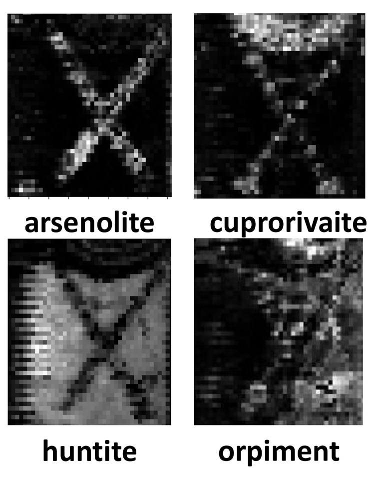
VIL





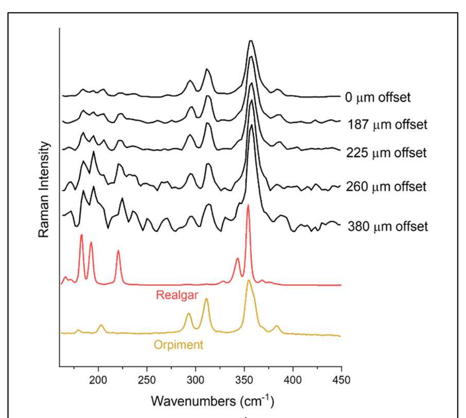
Copper-based green painted areas are characterized by the presence of chlorine, as revealed by MAXRF analysis. The MAXRF distribution of silicon further distinguishes at least two types of green Cu-Cl pigments. External reflection infrared spectroscopy reveals weak signals of Egyptian blue in the silicon-rich green areas (#74, #76), also supported by faint near-infrared luminescence in the VIL image, along with the presence of copper oxalates (Cu-oxa). In contrast, the silicon-poor greens are predominantly characterized by strong signals of copper oxalates and copper carboxylates (Cu-soap); typical OH stretching bands of atacamite and silicates are also observed in greens #70, #71, #78, and #90. It remains unclear whether these copper-organic greens formed as a result of chemical interactions between the pigment and the binder—suggested to be fatty compounds based on the shape and position of the CH stretching bands—or whether they were intentionally produced.

MAXRD



The MAXRD map of the chest reveals the presence of huntite in the white background, orpiment in the yellow cross as well as in residues emerging from the yellow background, and cuprorivaite (Egyptian blue) in the blue decorations. Notably, arsenolite (As_2O_3) was identified within the yellow cross as orpiment degradation product.

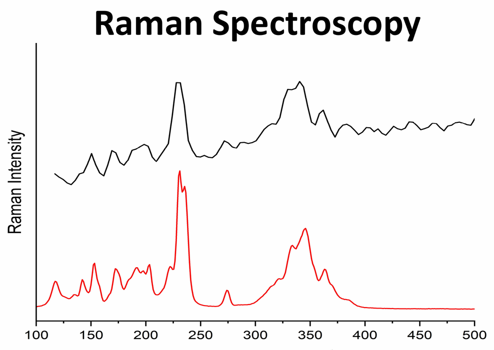
Micro-SORS

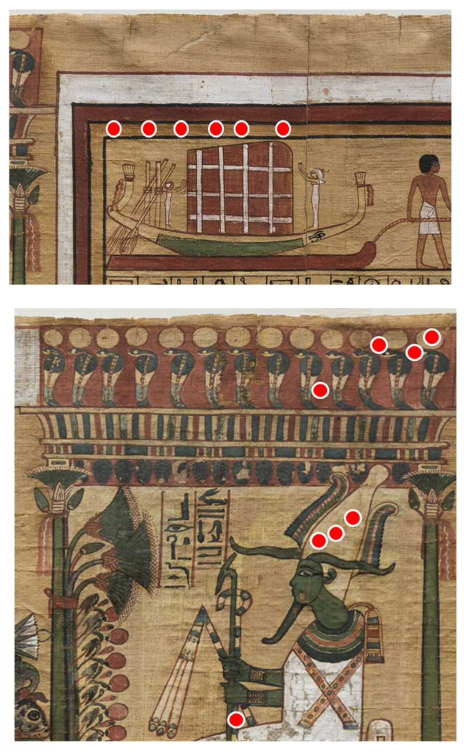


Micro-SORS sequence acquired on a yellow sun, indicated by the red dot in the image on the left. The 0 µm offset spectrum (imaged spectrum) shows signals from both orpiment and realgar (reference spectra of the two pigments are reported in yellow and red, respectively). As the offset distance increases, the realgar signal from the subsurface gradually intensifies, revealing the presence of a stratigraphy: the yellow suns, made of orpiment were painted over a red background composed of realgar.

Raman spectrum of pararealgar (reference in red) acquired in several areas of the papyrus; the red dots in the images represent the distribution of this compound across the analysed areas.

Raman Spectroscopy





Navigate the entire figure of Osiris on a smartphone using the 30x image captured with the high-resolution digital microscope.

Technical information about the instruments used in this MOLAB E-RIHS campaign can be found here https://www.e-rihs.it/en/laboratori-mobili/