

IN SITU MICRO- AND NON-INVASIVE ANALYSES FOR THE STUDY OF CARTONNAGES FROM THE NECROPOLIS OF ASWAN (EGYPT)

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1. Introduction

The chemical-physical characterisation of artefacts of historical-artistic interest is important as it can provide valuable information about the painting techniques used, the availability of natural pigments and the technological skills of a population. Research studies conducted in this field were able to identify the range of colors available to the ancient Egyptians [1-3].

The following study aimed to investigate the nature and composition of the pictorial layers of four different Egyptian artefacts found in West Aswan, Egypt, in the framework of the excavation of EIMAWA (Egyptian Italian Mission At West Aswan), which is in the area surrounding the Mausoleum of the Aga Khan. The necropolis covers a period of around 1000 years (6th cent. BCE-4th cent. CE). The analyzed artefacts were three different cartonnages excavated during two different campaigns: the first carried out in June 2021 during which analyses were performed using ATR/FTIR and a portable colorimeter for in-situ analyses, and the second one (May 2023) when analyses were performed using a multispectral camera.

2. Results and Discussion

Using the ATR/FTIR technique, it was possible to highlight the nature of the compounds present on the cartonnages and thus investigate the nature of the pigments used to decorate these artefacts.

As is well known, strict Egyptian laws prohibit transporting any kind of artefact to other countries, so the use of portable instrumentation for in-situ analyses was mandatory. Investigations through portable ATR/FTIR spectroscopy were carried out in the storehouse where the items coming from the excavation are kept. Measurements were performed on fragments already detached from the cartonnages and found inside the paper packaging where they were preserved.

To identify the pigments, the collected spectra were compared with reference spectra present either in our database or in the literature. Calcium carbonate due to the substrate of the cartonnages was detected in all the spectra while the pigments were recognized as red ochre, yellow ochre, fine Egyptian blue and madder. The latter is a natural dye of organic origin coming from the root of the madder plant (*Rubia tinctorum*). This compound typically contains alizarin and purpurin, which are two anthraquinones,

Visible reflectance analyses were performed on-site, i.e. at the excavation, by means of a portable spectrophotometer. From the obtained spectra, it was possible to confirm homogeneity in the pigments applied on the cartonnages. In addition, the colorimetric data were also processed with PCA (principal components analysis) to highlight possible differences among the different hues.

With UVL (UV induced luminescence) imaging, it was possible to observe the distribution of the pigment of an organic nature on the surface of the artefacts together with the presence of organic binders. The VIL (Visible Induced Luminescence) technique, on the other hand, made it possible to immediately point out the presence of Egyptian blue on the artefacts, and finally, the IRR (IR reflectography) technique allowed getting a better understanding of the preparatory drawing hidden beneath the pictorial layer and to investigate the behavior of the different pigments when stimulated by infrared radiation.

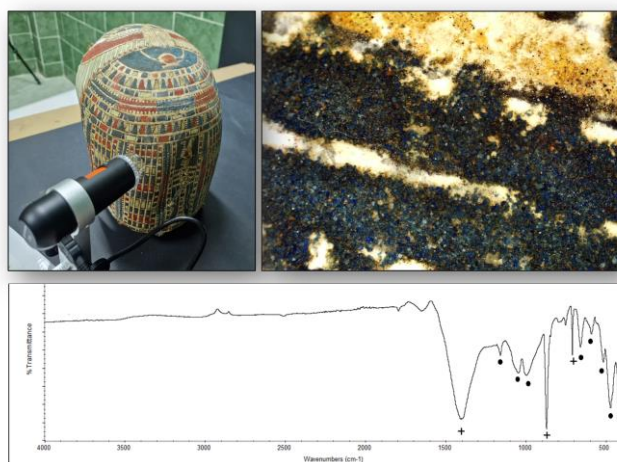
3. Conclusions

The analyses performed by ATR/FTIR revealed the presence of several pigments. Particularly interesting was the pink fragment: the spectrum itself was found to be different and it is suspected to be an organic dye, probably rose madder.

By studying the data obtained by reflectance spectroscopy, it can be stated that the pigments are the same for each color, and the palette remains confined to a limited range of minerals and dyes.

With UVL, VIL and IRR it was possible to observe the spatial distribution of some of the colors; specifically, areas mainly composed either of organic substances or of the abundant Egyptian blue were evidenced. Moreover, the drawing's shape hidden beneath the pigment layer was defined.

The investigation revealed the overall composition of the cartonnages' color palette, which was also found to be in line with the data in the literature.



Detail and ATR/FTIR spectrum of a blue fragment of cartonnage 1 (calcite (+) and Egyptian blue (•) bands).

References

- [1] Hallmann, A., Rickerby, S., Shekede, L. (2021). Blue and green in the decoration of a Kushite chapel in Karnak, Egypt: Technical evaluation using low-tech, non-invasive procedures. *Journal of Archaeological Science: Reports*, 39
- [2] Lombardi, C. A., Comite, V., Fermo, P., Bergomi, A., Trombino, L., Guglielmi, V. (2023). A Multi-Analytical Approach for the Characterisation of Pigments from an Egyptian Sarcophagus Cover of the Late Dynastic Period: A Case Study. *Sustainability*, 15
- [3] Pozza, G., Ajò, D., Chiari, G., De Zuane, F., Favaro, M. (2000). Photoluminescence of the inorganic pigments Egyptian blue, Han blue and Han purple. In *Journal of Cultural Heritage*, 1