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**AF 9590, a Yellow Coffin from the Egyptian Antiquities
Department of the Louvre Museum: analytical
methodology developed in the C2RMF within the
Vatican Coffin Project**

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AF 9590, a Yellow Coffin from the Egyptian Antiquities Department of the Louvre Museum: analytical methodology developed in the C2RMF within the *Vatican Coffin Project*

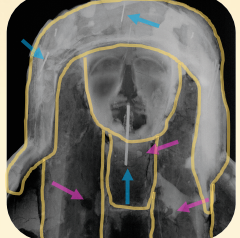
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The *Vatican Coffin Project* is a collaboration between European museums and laboratories for the study of the Theban “yellow coffins”. The objective of the project is to understand this Egyptian production from the 21st dynasty, with the ultimate aim of defining workshops, priests family practices and/or chronological evolution. These huge artefacts are three-dimensional composite objects; they are hard to handle as they have abundant colors and are partially varnished. It was therefore necessary to develop a specific, mainly non-invasive, methodology to understand the manufacturing process. AF 9590, a coffin from the Louvre Museum that is part of a 15-set corpus, illustrates the development of a multi-scale methodology at the *Centre de Recherche et de Restauration des Musées de France* (C2RMF).

Organic materials

X-Ray Radiography



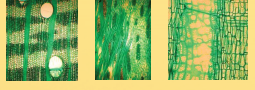
- Structure of the coffin, **assemblies (pegs)**
- Nature of wood panels
- Degradation, **conservation interventions** (nails in the head and metal stick for the beard, now removed)

UV Imaging



Presence of **organic materials: coating, dye or products** revealing **restoration areas**. The yellow fluorescence is due to the presence of original varnish.

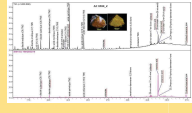
Wood anatomy



It identifies the different tree species used for coffin construction by microscopic observation of the three necessary sections: transverse, tangential and radial.

	Lid	Box
Planks	<i>Ficus sycomorus</i> L.	<i>Ficus sycomorus</i> L.
Pegs	<i>Acacia cf. nilotica</i>	-
Tenons	<i>Tamarix type aphylla</i>	<i>Quercus</i> sp. (Oak)

Varnish GC/MS analysis



GC/MS identifies the nature of the fluorescent varnish. The identified material is **mastic resin** which is an exudate from the *Pistacia lentiscus* sp.

Colour materials

IR Imaging



Infra-Red Imaging → highlights **carbon-black** presence which appears black

IRFC Imaging



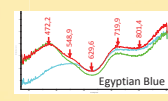
Infra-Red False Color Imaging → **Egyptian Blue** appears purple and Fe pigments yellow

VIL Imaging

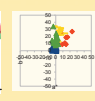


Visible induced Infra-red Luminescence Imaging → reveals only the **Egyptian Blue** because of the property of the **cuprorivaite** to re-emit IR radiation around c. 910 nm, appears in white.

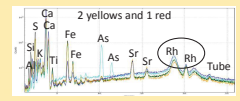
FORS



In-situ analysis



XRF



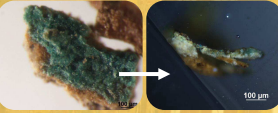
Fiber Optic Reflectance Spectroscopy permits to obtain diffuse reflectance spectra used to determine colorant agent. To avoid any subjective interpretation of the colours, the trichromatic coordinates L*a*b* (CIE: Colour Index European) are used to distinguish the different tones.

X-Ray Fluorescence (fixe or mobile - 3mm spot) is an elementary analysis technique, permitting to obtain a first idea about the global composition for each colour, without distinction about the stratigraphy.

Sampling study

In all cases

μ-sampling Cross-section



Observation

- Optical Microscope → Stratigraphy → Mixture
- SEM-FEG Imaging → Morphology → Grain sizes

Elementary analysis

SEM-EDS

Structural analysis

μ-Raman, FT-IR, XRD, GC/MS

Development

Methodology, techniques RBS, ESR

Arsenic sulfure materials

Two main problems with arsenic sulfure materials:
 - **Identify the material used**
 2 natural yellow arsenic sulfures exist → Orpiment (As₂S₃) and Pararealgar (As₂S₄)
 - **Know the precise position of the arsenic inside the stratigraphy**
 Orpiment in 3 distinct positions: 2 in the yellow background (mixed with Fe or as a pure layer) and in suspension in the varnish

Layer of varnish (UV) with yellow grains in suspension applied on a yellow layer (NL)



2 morphology types:
 - (a) sheet structure
 - (b) round shape grain

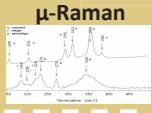


Same elementary composition: As - S

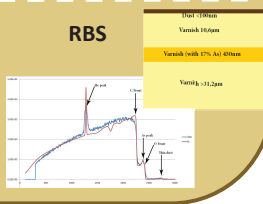


Presence of orpiment (As₂S₃) in the varnish and Pararealgar (As₂S₄) in the yellow layer is confirmed.

By the iconography of the sampling localisation it is sure Pararealgar (As₂S₄) has been properly used as yellow pigment.



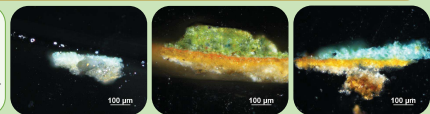
RBS (AGLAE) methodology is developed to know the exact position of the arsenic inside the stratigraphy by a non-destructive way. Lab preparations simulate the different stratigraphies and will be studied before the corpus. → Information which can be significative to identify workshops.



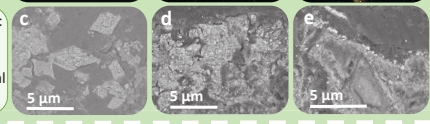
Copper green pigments

In-situ analysis → green pigments = **synthetic copper chlorides materials**
 Aim of μ-sampling study:
 - **Identify precisely the nature** of the green pigments
 - Understand the presence of copper chlorides (**original or neoformed materials**)
 - Identify the **process of synthesis**

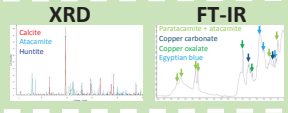
Various shades of green on the same object
 Thickness between 20-80μm



Various morphologies:
 (c) rhombohedric 1-5μm, (d) tiny grains <1μm, (e) with external crown 3-10μm



Traces of Sn → Synthetic pigment
 Copper green with Cl, S → Altered material
 Silica amorphous phase → Heat treatment



Identification of copper chlorides (atacamite and paratacamite)

Results of degradation: **neoformed chlorides**

ESR
 We seem to have two altered artificial materials (presence of bronze scraps): an organometallic material and a glass-type one made by heat treatment, and both with copper chlorides. Because of the difficulty in correctly identifying the copper greens, laboratory samples will mimic sintered and organometallic compounds, altered in chloride conditions. ESR, μ-Raman and FTIR, FEG-SEM imaging make it possible to define the original structure of the pigment.

Imaging data | Organized | Disorganized | Materials analysis data

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This entire multi-scale, multispectral and multi-techniques methodology provides a complete understanding of the coffin and its production. For now, it was applied on a dozen of coffins and funerary sets from the Egyptian Antiquities Department of the Louvre Museum. Different painting treatments, regarding the background application, have been observed between the inner and outer walls of the box and also on the upper and lower parts of the lid. Classical Egyptian polychromy pigments were identified: calcite, huntite, red ochre, yellow ochre, carbon black, orpiment and three artificial pigments – Egyptian blue and two groups of copper greens. The binder was animal glue or gum. Beyond the workshop identification, the overarching goal of this study is the conservation of the corpus, which cannot occur without the prior analytical phase.

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