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ANALYTICAL STUDY AND CONSERVATION PROCESSES OF A PAINTED WOODEN GRAECO - ROMAN COFFIN

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Abstract

This paper describes conservation processes of an Ancient Egyptian painted wooden coffin dating back to Graeco-Roman period using several scientific and analytical methods in order to provide a deeper understanding of the deterioration status, and a greater awareness of how well preserved the object is. Visual observation and 2D Program as well as Optical Microscopy (OM), Environmental scanning Electron Microscopy (ESEM), X-ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR) were used in our study. Studies that include the identification of wood species, ground layer, red paint layer, binding medium and previous restoration materials were made. The coffin was previously conserved and stored in improper conditions which led to its further deterioration, the surface of the lid was extensively embedded with dust and bird droppings which obscured the decorations as well as missing and peeled painted gesso layers in many places and previous plaster fills obscured original surface. Soon after transportation from El-minia storage to the Wood Conservation Laboratory of the Grand Egyptian Museum-Conservation Center (GEM-CC), conservation procedures have been applied with high accuracy to conserve the coffin including cleaning, stabilization of the friable painted gesso layers, reattaching lifting paint layers, removal of previous restoration and filling cracks and voids. The materials and methods that had been applied were extremely effective to stability and reinforcement of the coffin without harmfulness on the original materials and the coffin was successfully conserved and ready to display or storage in the Grand Egyptian Museum (GEM).

Keywords: *Painted coffin; Deterioration; 2D Program; Sycamore fig; XRD; Treatment.*

Introduction

At all times in ancient Egypt, the designs and structure of coffins varied and reflected the chronology of historic periods, the social level of the owner and religious beliefs, for example some were long and rectangular, others were anthropodial [1] that replaced the simple box shape during the New Kingdom and predominated in Greco-Roman period. They were painted with scenes of Egyptian funerary iconography but with classical motifs incorporated [2-6]. Moreover, the type of wood was different in the different periods. Royal and noble coffins were made of fine imported wood, but coffins of middle class or poor people were made of local wood, which was of lesser quality and properties [1]. The studied coffin (GEM No 32598) dates back to the Graeco-Roman period from El-minia storage and was transported to the Grand Egyptian Museum – Conservation Center (GEM.CC) in 2010. The coffin consists of box and lid (Fig.1) and contains a mummy inside it. Both outsides of the coffin box are decorated with multi-colored inscriptions in vertical registers. The exterior surface of the coffin lid is decorated

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with multi-colored collars, the goddess Nut on her knees spreading out her wings down to the deceased chest, the four sons of Horus, hieroglyphic inscriptions and the god Anubis on his shrine, while the underside of the coffin box is decorated with a protective goddess. Three rectangular mortises on each side of the top edge of the coffin box correspond to sites where wooden tenons were slotted into place to secure the lid, circular holes piercing the walls of the coffin box once held dowels that were used to lock these tenons when the lid was closed. At the shoulders, there are angular lap joints. The coffin dimensions are about 184 cm in length and 41 cm in width (Fig. 1).

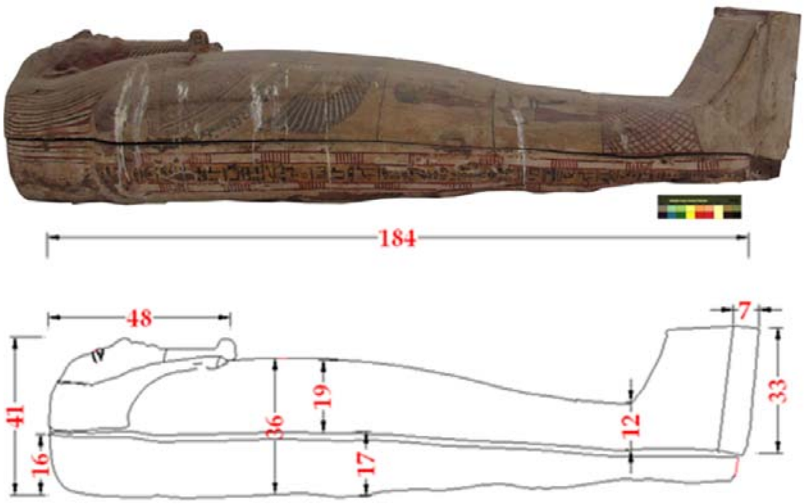

Fig. 1. The coffin consisting of box and lid and its dimensions

This paper aims to characterize the original materials and the materials added during the previous restoration interventions used in the painted wooden coffin using several scientific and analytical approaches to provide a deeper understanding of the deterioration status to choose the most appropriate cleaning and consolidation measures and to decide the removal of previous materials that disturbed the authenticity of object. Moreover, the authors were especially interested in the identification of the wood species used in the coffin.

Materials and methods

In this study different analytical approaches such as Optical Microscopy (OM), Environmental Scanning Electron Microscopy (ESEM), X-ray Diffraction (XRD) and Fourier transformed infrared spectroscopy (FTIR) were used to elucidate the nature of the original and added materials as well as to establish the conservation state of the coffin.

Visual assessment

Visual assessment, by the critical eye of the team work, was applied to determine the aspects of deterioration found on the Coffin's wood and decorative layers. This method is very effective because the causes and mechanism of deterioration may be easily identifiable. The critical eye of conservator - restorer can also determine the most effective techniques of analysis, which should be applied for identifying the condition of the coffin studied.

Documentation of the deterioration aspects by 2D program.

Computer Aiding Drawing program was used to illustrate the deterioration aspects of the coffin, a map of the damage was made and each side of the coffin was documented, special key note was assigned to every type of deterioration aspects, a Map of conservation procedures was also developed to express the conservation procedures applied on the coffin.

Optical Microscopy (OM)

Optical Microscopy (OM) using a Zeiss Stero DV 20 (stereomicroscope) equipped with Axio Cam MRC5 was used to study the stratigraphic structure of the painted gesso layers, and in transmitted light using OPTKA MICROSCOPY (Italy) equipped with OPTIKA B 9 Digital Camera to identify the wood species. Thin sections were obtained in the three principal anatomical directions, transverse (TS), tangential (TLS) and Radial (RLS).

Environmental scanning electron microscopy

A Quanta 3D 200i scanning electron microscope made by FEI was used for examining the wood used in the studied coffin, and for studying the stratigraphic structure of the painted layers. The accelerating voltage was between 10-15 kV in the magnification range of 80 to 200 x. The investigation was carried out in both the large filtered detector mode (LFD) and the back scattered electrons mode (BSE).

X-ray diffraction analysis

X-ray diffraction using X-ray Diffractometer System PW3040–Analytical Equipment–PANalytical pro model, Cu-target tube and Ni filter at 40 kV and 30MA were used. (X'Pert Highscore) software was used for identifying the components of the painting ground layers and previous restoration materials.

Fourier transformed infrared spectroscopy

IRPrestige-21 (FTIR spectrophotometer) and the IRsolution software in the 400–4000cm^{-1} range with resolution of 8cm^{-1} were used for identifying the medium used in the painted gesso layers and previous restoration materials and also for identifying the previous wax material.

Results and discussion

Deterioration aspects

The coffin was previously restored and stored in bad conditions which led to advanced deterioration. The following deterioration aspects were noticed on it: the surface of the lid was extensively embedded with dust and bird droppings, which obscured the decorations (Fig. 2A-D) especially the lid face because of the accumulation of wax that had been used from previous fault restoration to fixate the paint layer in the coffin lid , as well as cracks, missing and lifted painted gesso layers in many places and previous plaster fills obscured original surfaces, altered the color and saturation of polychrome areas, besides several areas of retouching with new pigments over the previous plaster fills (Fig. 2E).The underside of the coffin base had not been previously restored and the painting layer and the ground layer were in an unstable and deteriorated condition with many areas insecurely attached, flaking and tended to shatter when touched (Fig. 2F). In some areas the painting layer and the ground layer were friable, powdered (Fig. 2G) and entirely lost besides other forms of damage including cracks and separation of wood panels (Fig. 2H, I).

Documentation of the Deterioration aspects by 2D program.

The condition of the coffin was recorded in detail and each part was carefully recorded using 2D program. This technique produced clear documentation of the deterioration aspects as shown in Figure 3.

Identification of wood species

It was very common in ancient Egypt to use native woods such as acacia, tamarisk and sycamore fig covered with a gesso layer that concealed the flaws often found in these woods and that acted as a ground for decoration [7]. Microscopic identification indicated that the wood used in the coffin boards was Sycamore Fig (*Ficus sycomorus* L). This timber is recorded as being native to Egypt and was used to make coffins since at least the Fifth Dynasty [8].

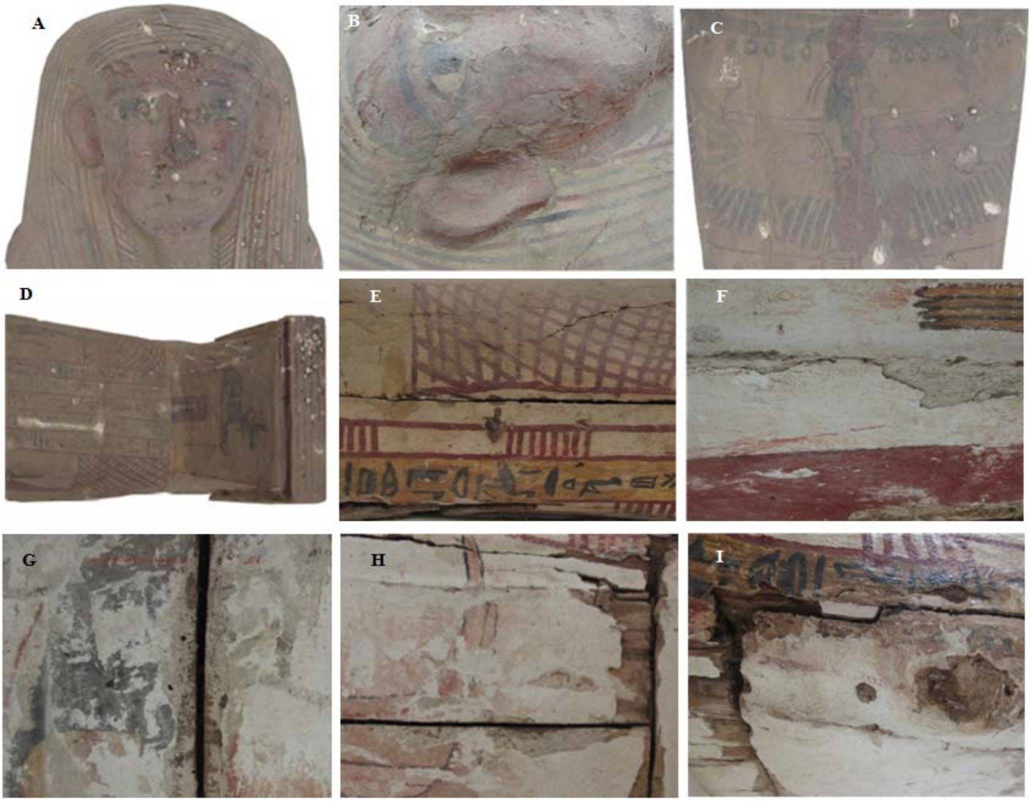

Fig. 2. Aspects of deterioration found on the coffin: A-D - Dust and Bird droppings; E - Retouching with new pigments; F - Flaking and Peeled layers; G - powdering and discoloration; H and I - Missing parts, separations of wooden panels, cracks

The diagnostic characteristics used to identify *Ficus sycomorus L* were diffuse porosity, vessels solitary or in radial multiples of 2 to 4, axial parenchyma vasicentric in bands more than three cells wide in TS (Fig. 4A). Rays of two distinct sizes, larger rays commonly 4 to 12 seriate [9] and some lacticifers present in TLS (Fig. 4B and C). Heterocellular rays with square and upright cells only on marginal rows as seen in RLS (Fig. 4D) [10]. Examination using SEM showed that the wood appeared to be in good condition, no fungal decay was evident and the cells were intact showing no signs of deterioration (Fig. 5A and B). SEM allowed also identifying laticifers in rays as seen in TLS (Fig. 5C). As for the wood of the dowels used to join the coffin boards together was identified as *Tamarix sp*. The species of *Tamarix* present in Egypt, the Sahara and adjacent regions are virtually impossible to separate reliably on the basis of their wood anatomy. Neumann et al. have suggested a separation into a *T. aphylla* type (including T. *aphylla* and *T. passerinoides*), which shows very broad rays, sometimes exceeding 20 cells, and a second *Tamarix* type that includes several species with narrower rays [11]. In this study, *Tamarix* has been identified to the second type. The properties of the *Tamarix* wood include medium bending and compression strength, moderate hardness and a coarse and fibrous texture such properties made *Tamarix* wood a favored choice in ancient Egypt for making dowels and pegs over a wide chronological time span [8]. The diagnostic characteristics used to identify *Tamarix sp* were wood semi-ring porous, vessels solitary and in small clusters (Fig. 6A), Axial parenchyma scanty paratracheal to vasicentric in TS (Fig. 6B) [9], larger rays commonly 2 to 7 seriate, Axial parenchyma storied in TLS (Fig. 6C), simple perforation plates and Inter-vessel pits alternate (Fig. 6D) [10].

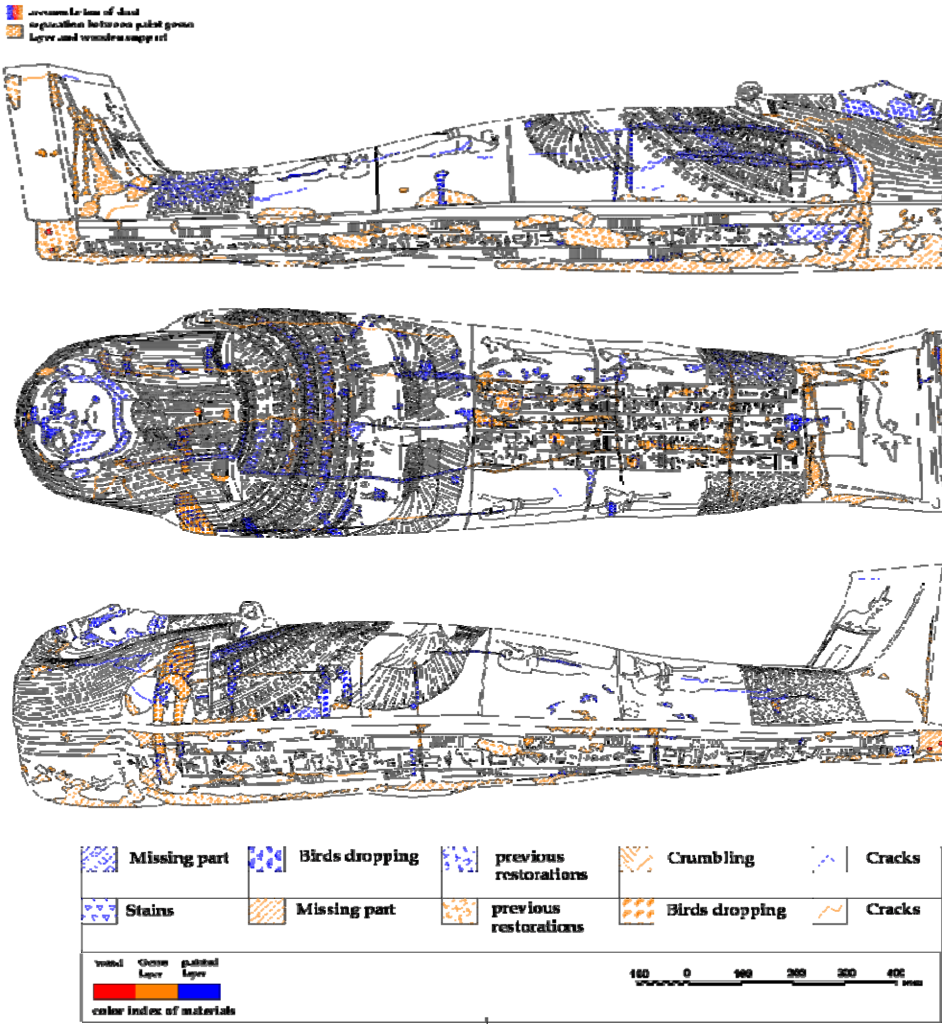

Fig. 3. Schematic diagrams of the coffin showing the deterioration aspects by 2 D program: A - Schematic diagram of the coffin left side; B - Schematic diagram of the coffin lid; C - Schematic diagram of the coffin right side.

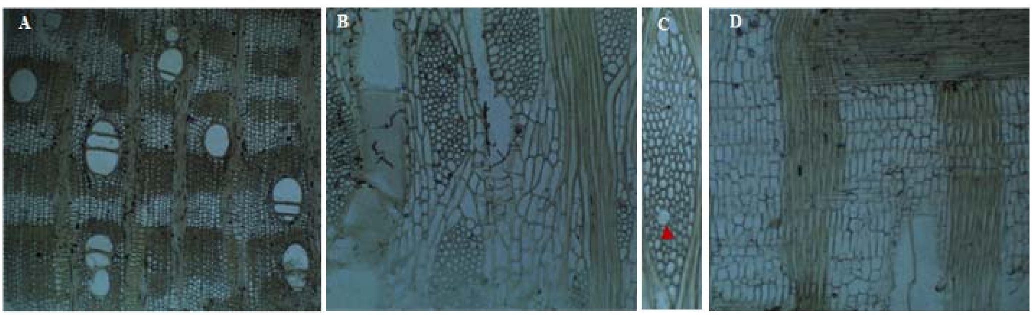

Fig. 4. ***Ficus sycomorus:*** A - Transverse section (TS) showing vessels solitary or in radial multiples of 2 to 4 and axial parenchyma vasicentric in bands more than three cells wide (40 x); B - Tangential section (TLS) showing rays of two distinct sizes, larger rays commonly 4 to 12 seriate(40 x); C - laticifers were observed in rays (arrow head). (200 x); D - Radial section (TLS) showing body ray cells procumbent with one to 4 rows of upright and square marginal cells (100 x).

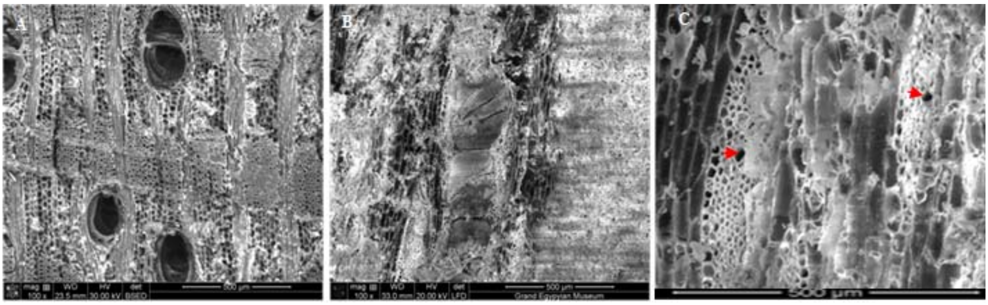

Fig. 5. SEM microphotographs of *Ficus sycomorus L* wood: A and B - Transverse section and Tangential section (TLS) showing no evident fungal decay; C - laticifers were observed in rays (arrows).

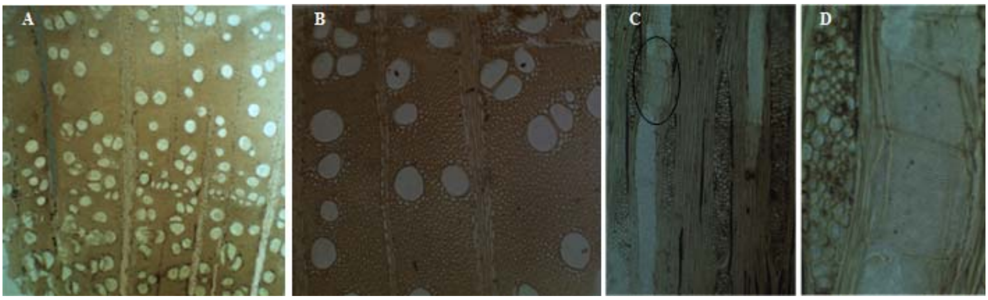

Fig. 6. Tamarix sp.: A - Transverse section (TS) showing semi ring porous, vessels solitary and in small clusters; B - Details of transverse section(TS) showing axial parenchyma scanty paratracheal to vasicentric (100X); C - Tangential section(TLS) showing rays commonly 2 to 7 seriate, Axial parenchyma storied (100X); D - detail of Tangential section (TLS) showing simple perforation plates (400X).

The stratigraphic structure of the paint layers

The preliminary observation of the coffin showed the presence of a coarse ground layer directly covering the wood possibly to smooth out unevenness in the joints and to suppress wood defects, followed by another white fine ground layer to get smooth surface for painting process. The use of several textured gesso layers mitigates the destructive effect of the natural movement of the wood because the uneven particles of calcium carbonates prevent shrinkage of the gesso layers [12]. From the microscopic observation, the investigation of the red pigment sample shows that the red pigment in the form of a thin single layer with thickness ranging from 5 μm to 13.1μm applied on white smooth ground layer with a thickness ranging from 432 μm to 570 μm (Fig. 7A and Fig. 8A).

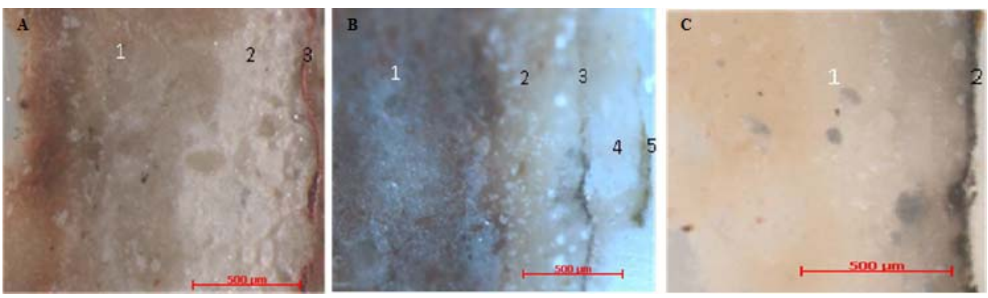

Fig. 7. Stratigraphic structure of the painted ground layers by OM: A - Red pigment showing three layers (1- coarse ground layer, 2- fine ground layer, 3-thin paint layer); B - Green pigment showing five layers (1- coarse ground layer, 2- fine ground layer, 3-thin paint layer, 4- previous ground layer, 5-previous paint layer; C - Black pigment showing two layers (1- fine ground layer, 2- thin paint layer.

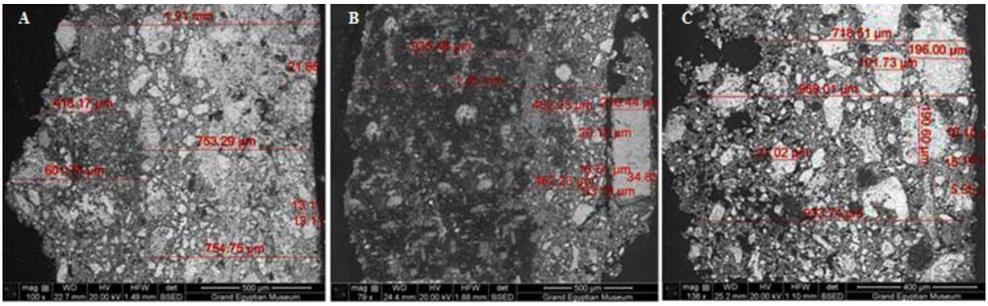

Fig. 8. Backscattered electrons (BSE) micrographs showing the stratigraphic structure and thickness of the painted ground layers: A - BSE micrograph of Red pigment; B - BSE micrograph of Green pigment; C - BSE micrograph of Black pigment.

The investigation of the green pigment sample shows that the pigment in the form of a thick single layer with thickness ranging from 16.5µm to 44.4µm applied also on a white smooth ground layer with a thickness ranging from 432µm to 462.2µm and covered with previous gap filling materials with a thickness ranging from 216.4µm to 250.2µm (Fig. 7B and Fig. 8B). The investigation of the black pigment sample(from the underside of the coffin box) shows that the pigment in the form of a thin single layer with thickness ranging from 5.35µm to 16.1µm applied on white course ground layer with a thickness ranging from 718µm to 968µm (Fig. 7C and Fig. 8C).

Identification of painted gesso layers

In the studied coffin, there are many pigments on the ground layer which are red, green, yellow and black pigments but we couldn't examine these pigments except the red pigment, as there are not enough fallen fragments of those pigments. XRD analysis revealed (Table 1) that the inner coarse ground layer (Fig. 9A) was made of calcite ($CaCO_3$) as a major component with small amounts of quartz (SiO_2). The fine ground layer used under the pigments directly (Fig. 9B) was made of calcite ($CaCO_3$) only, the red pigment (Fig. 9C) was a hematite (Fe_2O_3) that was very common in ancient Egypt as a red pigment [13] and used from the 5th Dynasty till the Roman times [14]**.** The previous plaster fills (Fig. 9D) were made of gypsum ($CaSO_4.2H_2O$), which was commonly used as gap filler for loss compensation in last decades.

Table 1. X-Ray Diffraction results of samples taken from ground layers, paint layers

Kind of samples	Compounds
Coarse gesso layer	Calcite ($CaCO_3$), Quartz (SiO_2).
Fine gesso layer	Calcite ($CaCO_3$).
Red pigment	Calcite ($CaCO_3$), Hematite (Fe_2O_3).
Previous plaster fills	Gypsum ($CaSO_4$.$2H_2O$).

Identification of binding media

FTIR spectra revealed that the binding medium used in the red pigment (Fig. 10A) was identified as animal glue taking into consideration that the fine gesso layer was mainly calcium carbonates and that the presence of the carbonates group caused shift in the absorption bands (CO_3 Stretching band 1490-1370 cm^{-1}) [12,15], this binder was commonly utilized from early period, both in gesso and paint layers [16].The wax used in the previous consolidation identified (Fig. 9B) was identified as paraffin wax after a comparison with the control sample; also, the binding medium used in the previous plaster fills (Fig. 9C) was identified as poly vinyl acetate after a comparison with the control samples taking into consideration that the previous plaster fills were mainly gypsum and that the presence of the sulphate group caused shift in the absorption bands (SO_4 Stretching band 1140-1080 cm^{-1}) [15].

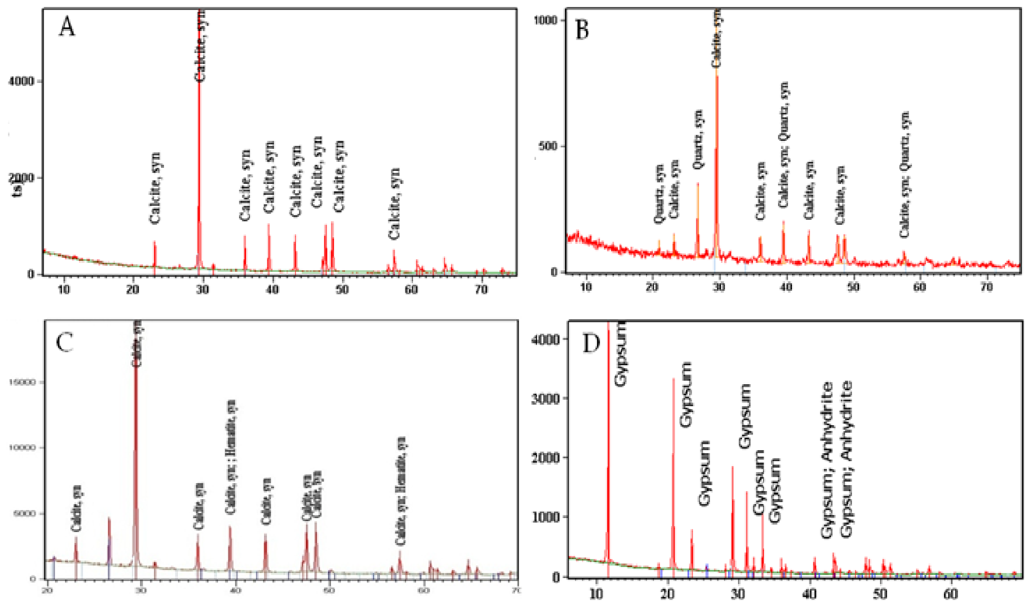

Fig. 9. XRD patterns of the painted coffin components: A - the inner coarse ground layer; B - the fine ground layer; C - the red pigment; D - previous plaster fills.

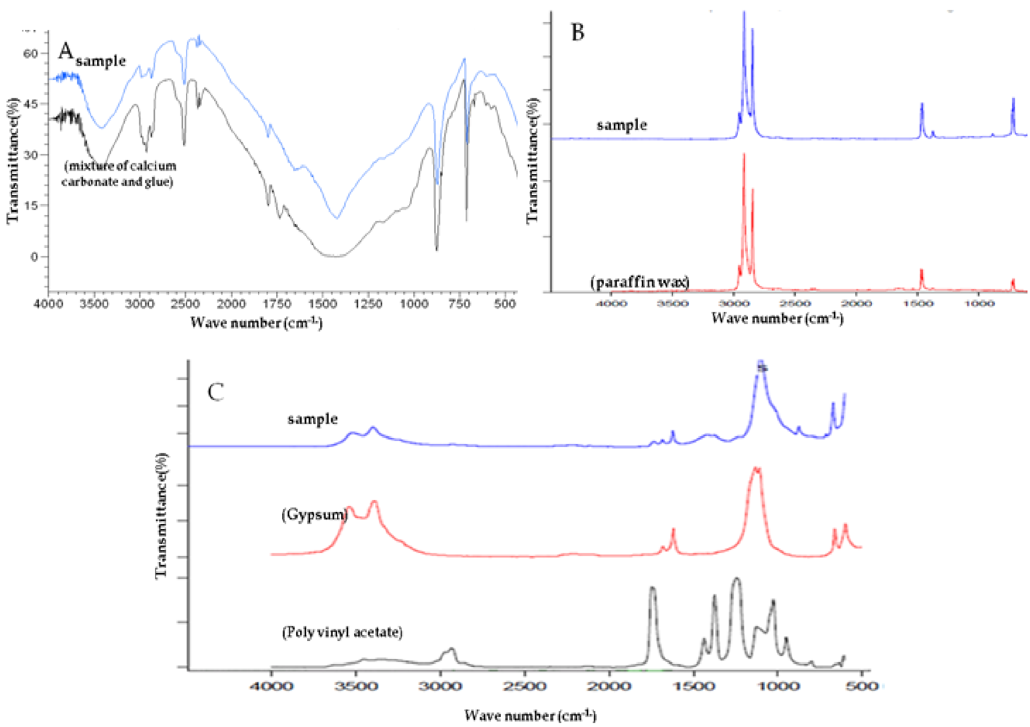

Fig. 10. Comparing FTIR spectra between references and samples from: A - Binder of red pigment; B - previous wax; C - Binder of Previous plaster filling materials.

Treatment and Conservation

The main purpose of conservation is to preserve art and other artifacts in such a condition that coming generations may experience them and study their value therefore, different procedures for treating and conserving the studied coffin were employed as soon as it was transported to the wood laboratory of the Grand Egyptian Museum-Conservation Center (GEM-CC), entailed cleaning, stabilization of the friable painted gesso layers, reattaching lifting paint layers, removal of previous restorations and filling cracks and voids.

Surfaces Cleaning

As this coffin had been stored in non-suitable conditions, a large amount of dust and bird droppings were found over the surfaces of the coffin especially the lid, loose dust was removed by gentle brushing (Fig. 11A) and vacuuming with a low-power cleaner fitted with a flexible rubber nozzle (Fig. 11B) [17]. Bird droppings were mechanically removed with scalpels, fine brush and a vacuum cleaner. Mechanical cleaning was proceeded by chemical cleaning in order to remove the remaining bird droppings and stains still attached to the surface of the painted layer. Before applying the chemical cleaning spot tests were done to determine the most efficient solvent to use in cleaning and to determine if the solvent may be used on the object without adversely affecting the object materials or appearance. The test was done on a small area $3mm^2$ of the object under magnification in a inconspicuous location [18]. Depending on this test a cotton swabs immersed in ethyl alcohol + Toluene +N N Dimethyl Formamide (1:1:2) was rolled over the surface to remove the accumulated grime and stains (Fig. 11C and Fig. 12). Some spots of bird droppings had to be left in situ because they had become embedded in the paint layer and could not be removed without damage to the original pigments.

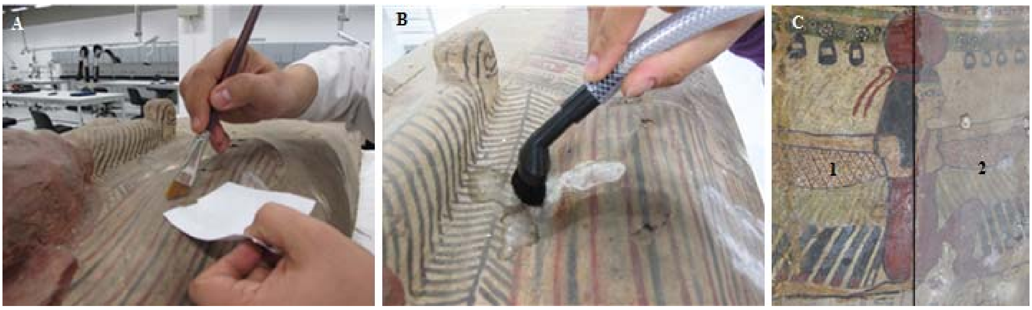

Fig. 11. Procedural steps of cleaning: A,B - During mechanical cleaning with a paintbrush, and vacuum cleaning; C - Chemical cleaning (1-after, 2-before).

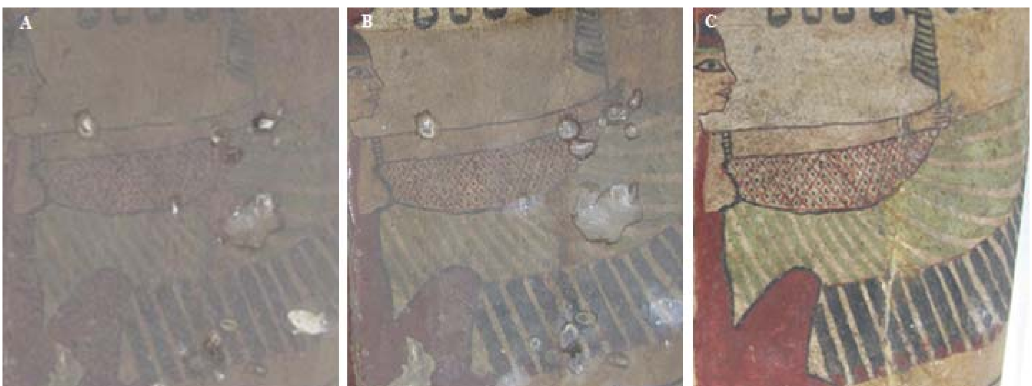

Fig. 12. Painting enhancement after cleaning procedures: A - Before cleaning; B - After hand brushing and mechanical cleaning; C - After chemical cleaning.

Stabilization of the friable painted gesso layers

The painted gesso layer lost its adhesion to the support in many places of the coffin. Primary fixation of the separated painted gesso layer flakes was done by carefully adhering strips of Japanese paper to the separated gesso flakes with a solution of 0.5% Klucel G in ethanol (Fig. 13A). Prior to applying the adhesive, separated painted gesso layer flakes were dampened from behind with ethanol to reduce the surface tension of the adhesive and to allow it to flow underneath the painted gesso layers. An emulsion of 20% Primal AC33 in distilled water was applied by injection (Fig. 13B) and then the separated painted gesso layers were eased back into position with the help of a little gentle pressure using silicone paper. For the friable and powdering areas 1% w/v Klucel G dissolved in ethanol was applied on the surface using a brush (Fig. 13C).

Fig. 13. Procedural steps of stabilization of painted gesso layer: A) during securing flakes by tissue paper; B) During reattaching the separated gesso flakes by injection; C) During consolidation with brush.

Reattaching lifting paint layers.

In order to reattach lifting paint layer, prior to applying the adhesive, lifting paint layer dampened from behind with ethanol to reduce the surface tension of the adhesive and allow it to flow underneath the paint layers, 3% methyl cellulose in distilled water was applied behind the layer by injection then treated surfaces were gently pressed with silicone paper on a fingertip to manipulate the now slightly flexible lifted flakes back onto the support (Fig. 14).

Removal of previous restorations

Knowing that the binder used for gap-filling in previous restoration was poly vinyl acetate, Acetone was used to assess the solubility of the binding material. A pad of cotton saturated with acetone covered with foil (Aluminum sheet) was helpful in softening the gap filling materials, which were then reduced and removed by mechanical methods e.g. scalpel, dental tools, etc (Fig. 15). For removing paraffin wax used as a previous consolidation material in some parts, mechanical methods e.g. scalpel and dental tools were used to reduce it and then a cotton swabs immersed in toluene rolled over the uneven surface tended to remove it. The thin layer of paraffin wax on the painted layer had to be left in situ because it had become embedded in the paint layer and could not be removed without damage to the original pigments.

Fig. 14. Procedural steps of reattaching the lifted paint layer:
A - Before; B - During pressing with silicone paper; C - After treatment.

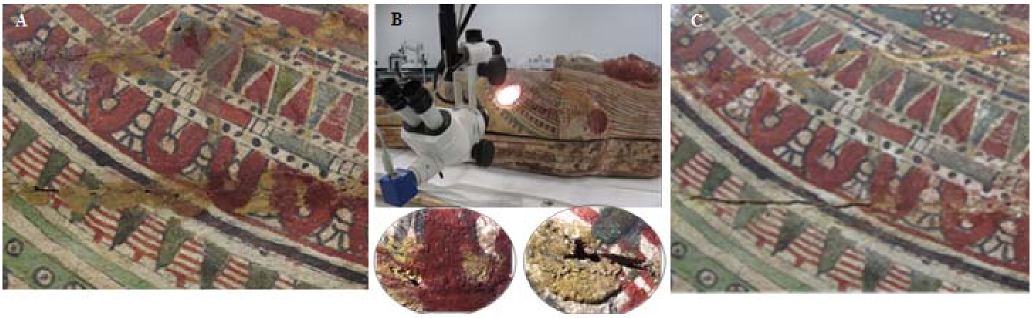

Fig. 15. Procedural steps of removal of previous restorations: A - aspect before removal of previous treatments; B - Investigation under stereo microscope of previous restorations; C - Aspect after removal of previous restoration.

Filling cracks and voids

Filling cracks and voids of this coffin depended mainly on the gap-filling materials applied, which were required to be reversible, exhibit minimal shrinkage, easy to carve, strong - yet weaker than the wood, whenever possible, exhibit good adhesive properties [19], long-term flexibility, good light fastness, receptivity to in-painting or coloring, can be worked with a spatula and sanded [20]. In order to fill the missing parts in the painted gesso layer adjacent to weaken painted gesso layer a fine putty consisting of 15% w/v paraloid B72 in acetone, glass micro balloons and earth pigments was applied , shaped and smoothed with a small spatula and swabs. In order to fill the large voids, cotton fibres were applied ,injected with paraloid B72(Fig. 16A) and then the same putty was applied, shaped and smoothed with a small spatula as final layer (Fig. 16B).

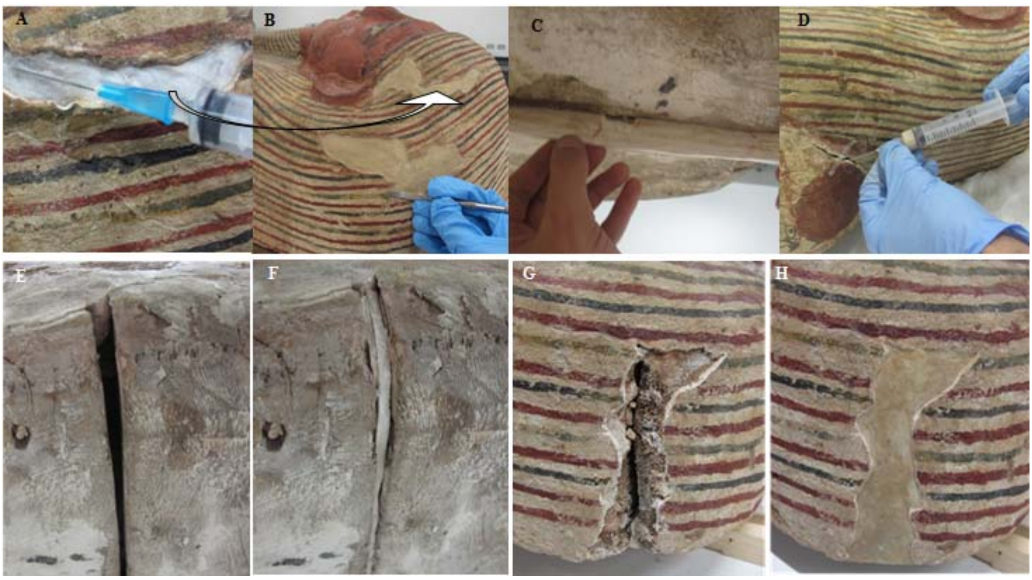

Fig. 16. Procedural steps of applying gap filling materials: A) Injecting cotton fibres; B) Applying gap filling materials by spatula; C) Inserting balsa wood; D) Applying gap filling materials by injection; E) Aspect before applying balsa wood; F) Aspect after applying balsa wood; G) Aspect before applying gap filling materials; H) Aspect after applying gap filling materials.

To fill the separation between the wooden panels in the basement of the coffin, Balsa wood which is light weight and easily compressed, yet does not experience the shrinkage associated with solvent-based fillers [21] was prepared with the same size of the separation between the wooden panels, and adhered with paraloid B72 (Fig. 16C), then the same putty was applied until the outer surface reached the expected level. The gaps between wood and high lifting gesso layer were filled injecting a fine putty consisting of 1% w/v Klucel G in ethanol and glass microballoon with syringes (Fig. 16D) .The above materials were chosen with the intention of providing a fill that would be weaker than adjacent areas of the original artifact. In the event of future stress, it is probable that this in-fill will fail in preference to materials used in the construction of the coffin [17].

Documentation of conservation stages

A map of conservation stages was illustrated by Drawings with 2D program (Fg. 17), special key notes were assigned to every type of deterioration aspects and also to express the conservation procedures applied on the coffin.

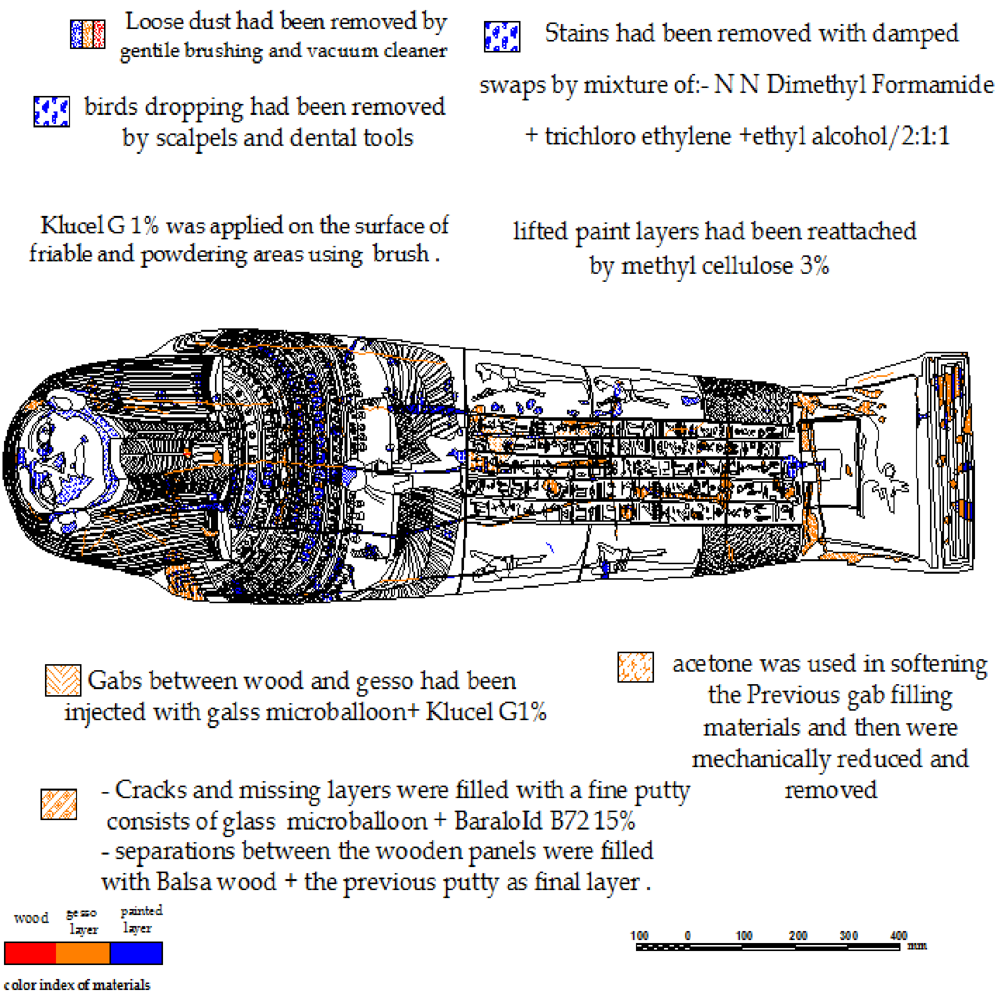

Fig. 17. Schematic diagram (by 2D Program) showing the conservation stages of the coffin lid.

In figure 18 is presented the lid of the coffin before and after the treatment.

Fig. 18. The lid of the coffin before and after the treatment.

Conclusions

A wooden painted anthropoid coffin (GEM .No. 32598) dating back to Graeco-Roman period (332 B.C -31A.C) from El-minia storage, consisting of lid and box and also containing a mummy inside it, was analysed and subjected to deep restoring. The wood species identification indicates that ancient Egyptian carpenter made the boards of the coffin with a native wood *Ficus sycamorus* not strong enough, but in case of dowels where load stresses occurred denser and strong wood native species *Tamarix sp*. had been used. This indicates that the ancient Egyptian carpenter was aware of the wood properties. The analysis with different methods using OM, ESEM, XRD and FTIR allowed characterizing the original materials, and the materials added during the previous restorations, which helped us to choose the most appropriate cleaning and consolidation measures and to decide the removal of previous materials that disturbed the authenticity of object. The materials and methods that had been applied were extremely effective for stability and reinforcement to the coffin without harmfulness on the original materials. The coffin was successfully conserved and ready to display or storage in the Grand Egyptian Museum (GEM).

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References

[1] H. Afifi, M.A. AbdElFatah, *Analytical Study of Ground Painting Layers and Conservation Processes of an Egyptian Painted Coffin*, **Journal of Life Sciences, 5**, 2011, pp. 661.
[2] J.H. Taylor, **Egyptian Coffins**, Shire Egyptology, Shire Publications Ltd., U.K, 1989.
[3] J.A. Corbelli, **The Art of Death in Graeco Roman Egypt**, Shire Publications, Princes Risborough, 2006.

[4] N.S. Geweely, H.A.M. Afifi, S.A. Abdelrahim, S.Y.M. Alakilli, *Novel Comparative Efficiency of Ozone and Gamma Sterilization on Fungal Deterioration of Archeological Painted Coffin, Saqqara Excavation, Egypt,* **Geomicrobiology Journal, 31**(6), 2014, pp. 529-539.

[5] L. Bonizzoni, S. Bruni, V. Guglielmi, M. Milazzo, O. Neri, *Field and laboratory multi-technique analysis of pigments and organic painting media from an egyptian coffin (26th dynasty),* **Archaeometry, 53**(6), 2011, pp. 1212-1230.

[6] K.M. Garland, J. Bernstein, J. Rogers, *Raising meret-it-es: examining and conserving an egyptian anthropoid coffin from 380-250 BCE*, **Journal of the American Institute for Conservation, 54**(2), 2015, pp. 102-113.

[7] W.V. Davies, *Ancient Egyptian timber imports: an analysis of wooden coffins in the British Museum,* **Egypt, the Aegean and the Levant: Interconnections in the Second Millennium BC** (Editors: W.V .Davies and L. Schofield*)*, British Museum Press, London, 1995, pp. 146-156.

[8] R. Gale, P. Gasson, N. Hepper, *Wood*, **Ancient Egyptian Materials and Technology** (Editors: T. Nicholson and I. Shaw), Cambridge University Press, 2000, pp. 334-371.

[9] A. Crivellaro, F.H. Schweingruber, **Atlas of Wood, Bark and Pith Anatomy of Eastern Mediterranean Trees and Shrubs with Special Focus on Cyprus**, Springer-Verlag Berlin Heidelberg, 2013, p. 55.

[10] A. Fahn, E. Werker, P. Bass, **Wood Anatomy and Identification of trees and Shrubs from Israel and Adjacent Regions,** Israel Academy of Sciences and Humanities, Jerusalem, 1986, pp. 132-133.

[11] C.R. Cartwright, J.H. Taylor, *Wooden Egyptian archery bows in the collections of the British Museum*, **The British Museum-Technical Research Bulletin, 2**, 2008, pp.77-83.

[12] M. Rifai, N.M.N. El Hadidi, *Investigation and analysis of three gilded wood samples from the tomb of Tutankhamen*, **Decorated Surfaces on Ancient Egyptian Objects Technology, Deterioration and Conservation** (Editors: Dawson, J., Rozeik, C. and Wright, M.M.), 2010, pp.16-24.

[13] L. Green, *Colour transformations of ancient Egyptian pigments*, **Colour and Painting in Ancient Egypt** (Editor: Davies W.V.), Oxbow Books, London, 2001, pp. 43-48.

[14] R.J. Gettens, G.L. Stout, **Painting Materials. A Short Encyclopaedia**, Dover, Ed, New York, 1966.

[15] R.M. Derrrik, D. Stulik, M.J. Landy, **Infra Red Spectroscopy in Conservation Science,** The Getty Conservation Institute, Los Angeles, 1999, p. 108.

[16] R. Newman, M.S. Halpine, *The binding media of ancient Egyptian painting',* **Colour and Painting in Ancient Egypt** (Editor:. Davies W.V), British Museum Press, London, 2001, pp.22-32

[17] C. Johnson, K. Head, L. Green, *The Conservation of a Polychrome Egyptian Coffin*, **Studies in Conservation**, **40**, 1995, pp. 75-82.

[18] M.L.E. Florian, **The Conservation of Artifacts Made from Plant Materials**, The Getty Conservation Institute, Princeton University Press, 1990, pp.225

[19] P. Hatchfield, G. Kyan, *Selected case studies in the treatment and preservation of Middle Kingdom polychrome wood in the collections the Museum of Fine Arts*, **Decorated Surfaces on Ancient Egyptian Objects Technology, Deterioration and Conservation** (Editors: Dawson, J., Rozeik, C. and Wright, M.M.), 2010, pp.78-86.

[20] A. Unger, A. P .Schniewind, W. Unger, **Conservation of Wood Artifacts. Hand Book,** Springer-Verlag, Berlin, 2001, pp. 464. `

[21] S. Gänsicke, *The conservation of decorated organic Egyptian surfaces: A literature review*, **Decorated Surfaces on Ancient Egyptian Objects Technology, Deterioration and Conservation** (Editors Dawson, J., Rozeik, C. and Wright, M.M.), 2010, pp. 67-77.

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