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ANALYTICAL STUDY AND CONSERVATION PROCESSES OF SCRIBE BOX FROM OLD KINGDOM

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ABSTRACT

The scribe box under study dates back to the old kingdom. It was excavated by the Italian expedition in Qena (1935-1937). The box consists of the lid and the body. The inner side of the lid is decorated with ancient Egyptian inscriptions written with a black pigment. The box was made by using several panels assembled together by wooden dowels and secured with vegetable ropes. The entire box is covered with a red pigment. This study aims to use analytical techniques to identify and have deep understanding for the box components. Moreover, the authors were significantly interested in using infrared reflectance transmission imaging (RTI-IR) to improve the hidden inscriptions on the lid. The visual observation and assessment were done to understand the condition of this box. 3D dimensions software was used to illustrate wood joints techniques. Optical microscopy (OM), X-ray diffraction (XRD), X-ray fluorescence portable (XRF) and Fourier Transform Infrared spectroscopy (FTIR) were used in this study in order to identify wood species, remains of insects bodies, red pigment, vegetable fibers and previous conservation adhesives, also RTI-IR technique was effective to improve hidden inscriptions. The results proved that wooden panels and dowels were Acacia (*Acacia nilotica*), wooden rail is willow (*Salix sp*). The insects are the cigarette beetle (*Lasioderma serricorne*) and spider beetle (*Gibbium psylloids*), the red pigment is Hematite, while the vegetable fibers were linen and previous adhesive was identified as cellulose nitrates. RTI-IR technique was effective to improve hidden inscriptions. The historical study for the inscriptions proved that it is a hieratic writings of a funerary text.

KEYWORDS: scribe box, Hieratic, 3D program, Acacia nilotica , XRD, cellulose nitrate, conservation

1. INTRODUCTION

At all times in ancient Egypt not everyone learned to read and write, only one group of people called scribes was allowed to have this knowledge. Scribes were people in ancient Egypt (usually men) who learned to read and write, they were the backbone of ancient Egyptian civilization (Lichtheim, 1976). Every scribe used the same tools. For pens, ascribe used finely sharpened reeds. for paper, he used a sheet of papyrus laid on writing tablets that made of wood or stone each tablet contained two wells, one for black ink and one for red ink a small container held water that was used to wet the ink (Szpakowska, 2008). The scribe carried his tools with him where ever he travelled. His tablet was hung from a cord slung over his shoulder attached to the tablet were leather bags or boxes that held his other tools. (Brier et al., 1999).The scribe box studied here back to the old kingdom (2686 - 2181 BC), that excavated by Italian expedition in Qena (1935-1937), it consists of 2 pieces lid and body, the lid have hieratic writings on the inside face written by black pigment, the studied box made with several panels assembled together by wooden dowels secured with vegetable ropes, and all box coated with red pigment, also we can see inside this box reed pens, red minerals as ink and papyrus re- mains, the box dimensions are 54 cm length, 24 cm width and 8 cm height. This study aims to use analytical techniques in order to identify and have deep understanding for the box component moreover; the authors were significantly interested in the condition of the object and ancient Egyptian inscription on the lid (Figures 1 and 2).

Figure 1. The box component

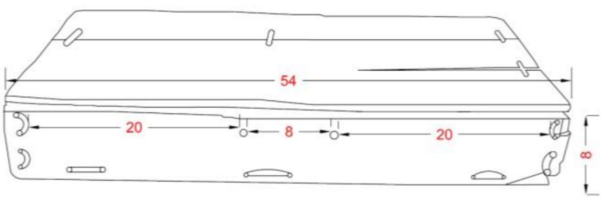


Figure 2. 2D drawing of the scribe box showing its dimensions

2. MATERIALS AND METHODS

Scientific analytical techniques, such as optical microscopy (OM), X-ray fluorescence spectroscopy (XRF), X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, and infrared reflectance transmission imaging (RTI-IR) technique were applied to elucidate the nature of the original and added materials, to explain the deterioration processes, as well as to establish the state of conservation of the scribe box.

2.1. *Visual assessment*

Visual assessment, by critical eye of the teamwork, was performed to determine the deterioration aspects of the scribe box; this method is very effective because the causes and deterioration aspects may be easily identifiable. The critical eye of conservator can also determine the most effective techniques of analysis to be applied for identifying the condition of the box under study (Abdel Maksoud, 2011; Lo Monaco et al., 2013).

2.2. *Documentation of the scribe box by utilizing software program*

Carpenter in this box used several jointing techniques for box connection, so 3D program was used to illustrate the jointing methods of the scribe box. (Abdrabou, 2015).

2.3. *Optical Microscope (OM)*

For optical microscopy (OM), a Zeiss Stereo DV 20 (stereomicroscope) equipped with an Axio Cam MRC5 was used to identify the insects remains that were found inside box. For transmitted light OPTIKA MICROSCOPY (ITALY) equipped with an OPTIKA B 9 digital camera was used to identify the vegetable ropes and wood species. Thin sections were obtained in the three principal anatomical directions: transverse (TS), tangential (TLS) and radial (RLS). The observation and description of the anatomical features for the sample were based on wood anatomy atlases (Ismail, 2016).

2.4. *X-ray diffraction analysis (XRD)*

X-ray diffraction using X-ray diffract meter system PW3040-analytical equipment-PANalytical promodel, Cu target tube and Ni filter at 45 kV and 30MA were used. X' pert High score software was used for identifying the component of the red pigment.

2.5. *Fourier transformed infrared spectroscopy (FTIR)*

The KBR technique was used for sample preparation. Spectrum was measured at a resolution of 4 cm-

1 and 20 scans were recorded per sample. IR Prestige-21 FTIR Spectrometer and the IR solution software were used. Spectrum in the range 4000-400 cm-1 was baseline corrected and atmospheric compensation was done, to identify previous conservation adhesive besides identifying and assessment of deterioration rates for vegetable fibers.

2.6. X-ray fluorescence analysis portable (XRF)

In order to identify the red pigment found on the scribe box X-Ray fluorescence measurement was carried out with portable system, thermo scientific Niton XL3t analyzer including X-ray tube with Ag anode, 50kV and 0-200µA max, at mining mode, spot diameter 3mm, duration of exposure 60 seconds (Abdallah, 2016).

2.7. Infrared reflectance transmission imaging (RTI-IR)

Reflectance Transformation Imaging (RTI) (Mudge et al, 2005) and one of its subdivisions, Polynomial Texture Mapping (PTM), developed in 2001 at Hewlett Packard Laboratories (Malzbender et al, 2001; PTM,2009), is a non-destructive, affordable and easy imaging technique, useful for conservators, archaeologists and curators. Previous work has already proved that RTI significantly contributes to analysis, conservation and representation (Earl et al, 2010) the recent RTI guide published by English Heritage (Duffy, 2003). Camera D90 Nikon was used as a modified camera, lens 60mm macro r, IR lamp, 2 spheres (blue), filter R90, tripod and laptop.

3. RESULTS AND DISCUSSION

3.1. Deterioration aspects

The scribe box was previously restored and the following deterioration aspects were noticed, the scribe box was covered with fine dust, box structure was unstable due to missing in several dowels and vegetable ropes. The ancient Egyptian writings and the red pigment were friable. One of the wooden rails was separated from the inside face of the lid and seen previous adhesive remains, the scribe box was set on 2 wooden rails assembled with the bottom by dowels, one of these wooden rails was missed and only remains of one of them if found (Figures 3A, B, C).

3.2.Documentation of the jointing technique

Egyptian carpenters discovered very early that glue could not be used on a timber's end grain, as the empty wood cells absorb and transport the glue away from the line of fixture making it difficult to obtain a satisfactory glue line (Reisner, 1910), in this case we found that the Egyptian carpenter used different jointing techniques to connect wooden panels with the bottom, connecting corners, also repair natural wood faults. Documentation by 3D program was very effective to show different jointing techniques in this box as follow:

A. B. C.

Figure 3A. dust on the box and missing wooden dowels and plant ropes,
B. separated wooden rail from bottom, C. separated wooden rail from lid

3.2.1 Half Lap Joint (rebated butt)

Probably the simplest formed cut joint is the half lap joint. An early example from the predynastic period was found connecting the corners of a burial box in grave N7454 at Nag el-Deir (Lythgoe, 1965). Studying the jointing methods used in this box indicated that half lap joints secured with wooden dowels and vegetable ropes were used to connect vertical wooden panels (the sides) together at the corners and also the same technique was used to connect the sides to the bottom (Figures 4 A, B, C).

3.2.2. Edge Joint (loose tongue or tenon)

Edge joint is used to connect long grain board to long grain board, The three cornerstones of edge joints, commonly referred to as "butt joints" are the Edge-To-Edge, Edge-To-Face, and Face-To -Face, each of these joints are formed by when each slab of wood is cut straight before being connected to its matched slab. The visual observation of studied box indicates that, both lid and bottom incorporates panels made from two irregularly shaped boards which have been matched together and then secured with pairs of loose tongues bottom (Figure 4 D). These tongues held in position by small dowels, at the middle of the lid, which pass through the sides of the boards and pierce the tongue above and below the line of fixture (Figure 4 E).

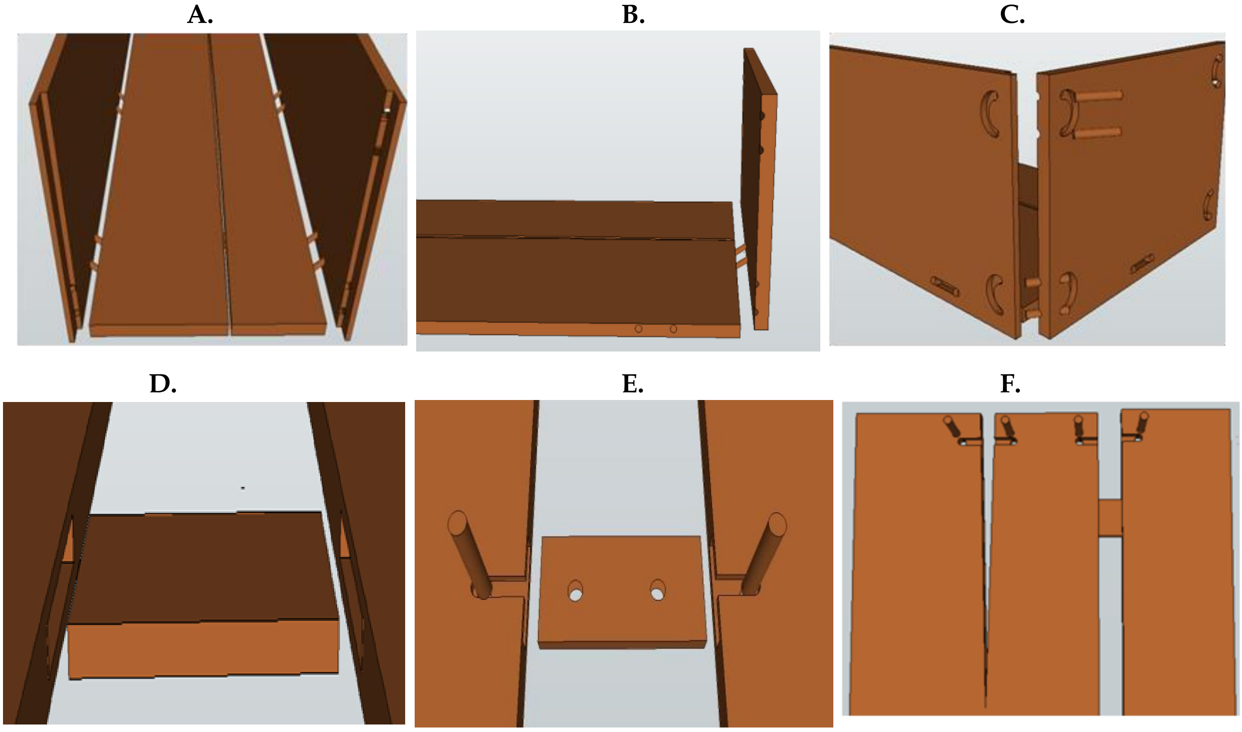


Figure 4. Jointing techniques illustrated by 3D program. A.B.C half lap joint, secured with wooden dowels and vegetable ropes, D. Edge Joint (loose tongue or tenon), E. edge joint with loose tongue secured with wooden dowels. F. repair of natural wood fault

3.2.3 Repair of natural wood faults

Natural wood faults such as cracks were secured by using wooden dowels which pierce the sides of the board above and below the line of fixture which secured with vegetable ropes (Figure 4-f).

3.3. *Improve hidden inscription by RTI-IR Technique*

Some of Hieratic inscriptions in the inside face of the lid were hidden, RTI - IR provides evidence about the texture of surfaces beyond the visible and proved to be a useful tool for this study (Figure 5), it enabled an advanced perception of IR information (Kotoula et al., 2014), so RTI-IR technique in diffuse gain, luminance un sharp and specular mode were very effective to improve some details about hidden inscriptions (Figure 6A: F), also the writing thickness (Figures 6 G-H).

Figure 5. RTI Application

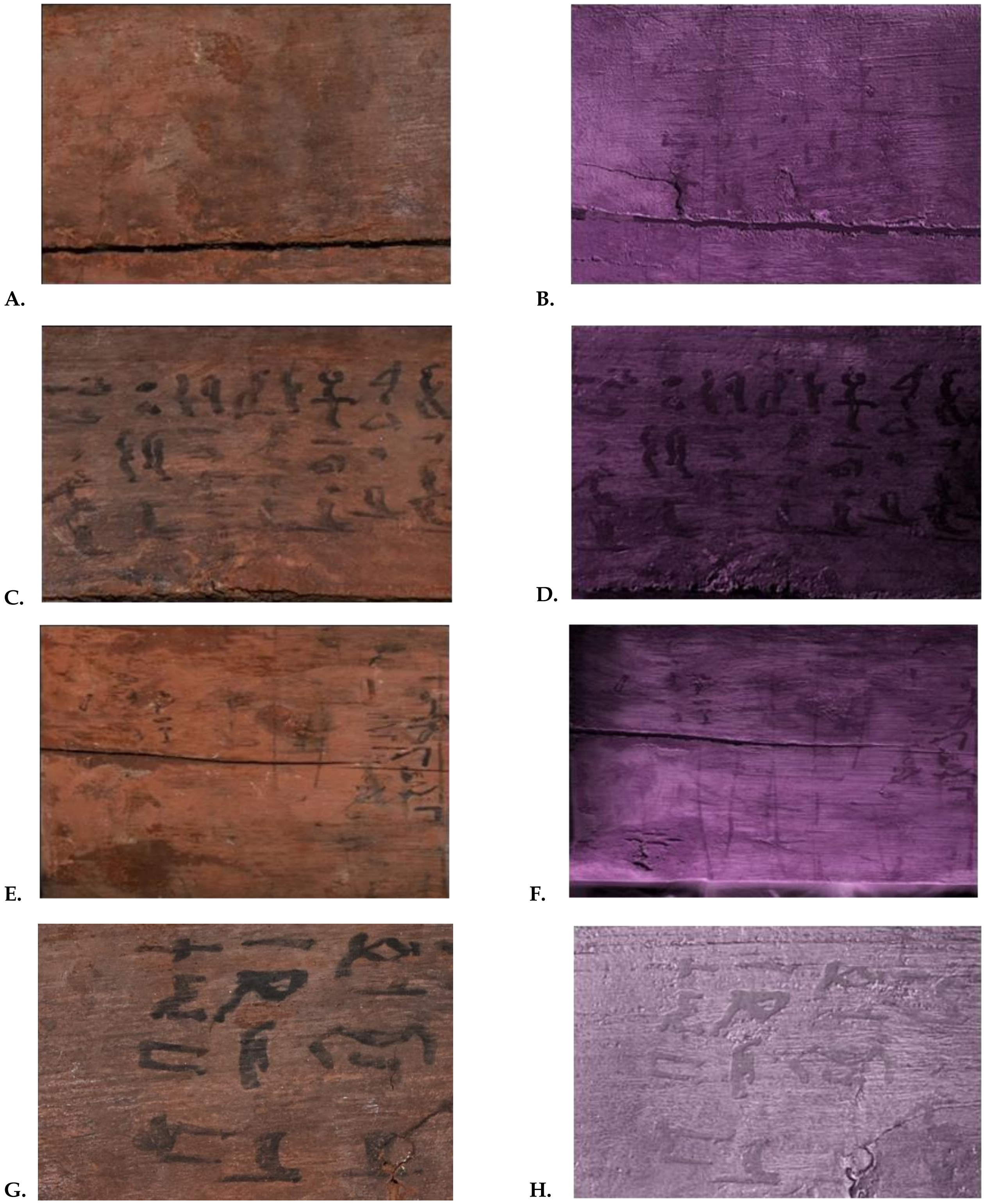


Figure 6. RTI applied modes
A. visible image, B. luminance un-sharp mode, C. visible image, D. diffuse gain mode, E. visible image, F. diffuse gain mode, G. visible image, H. specular mode.

3.4. Identification of wood species

3.4.1. Wooden Panels

It was very common in ancient Egypt to use native wood such as acacia, tamarisk and sycamore fig (Daves, 2001). Microscopic identification for thin sections indicated that the wood used in wooden panels was Acacia nilotica (Figure 7). Acacia is men- tioned in ancient texts as having been obtained in the Sixth dynasty from Hat nub in middle Egypt and from Wawat in Nubia and used for making boats and warships, also acacia wood was employed in Egypt not only for boat building, but also for the masts (Lucas, 1989).

3.4.2. Wooden rails

Wooden rail identified as willow (*Salix sp*) (Figure 8). The Egyptian willow whether_ indigenous or not in the country, is manifestly of considerable antiquity, as the handle of flint knife of proto dynastic date has been identified as probably willow, it was used for boxes, making camel saddles, funerary garlands and making tent poles (Lucas, 1989).

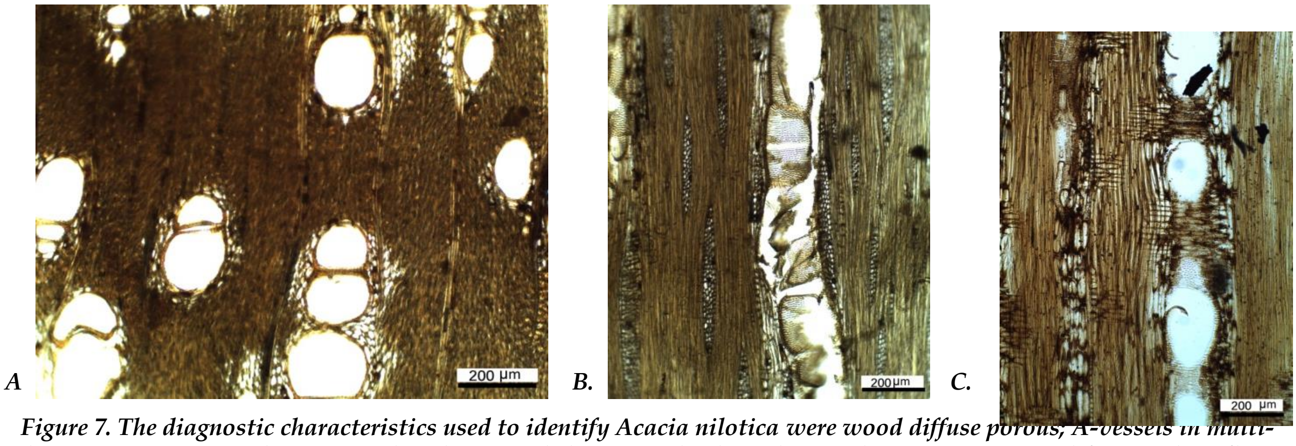


Figure 7. The diagnostic characteristics used to identify Acacia nilotica were wood diffuse porous; A-vessels in multiples (2–4) sometimes solitary, vessel outline rounded; paratracheal axial parenchyma vasicentric, aliform and confluent as seen in TS, B- multiseriate rays 2–4 seriate, simple perforation plates and intervessel pits alternate as seen in TLS; C- homocellular rays with procumbent cells; some prismatic crystals present in chambered axial parenchyma cells as seen

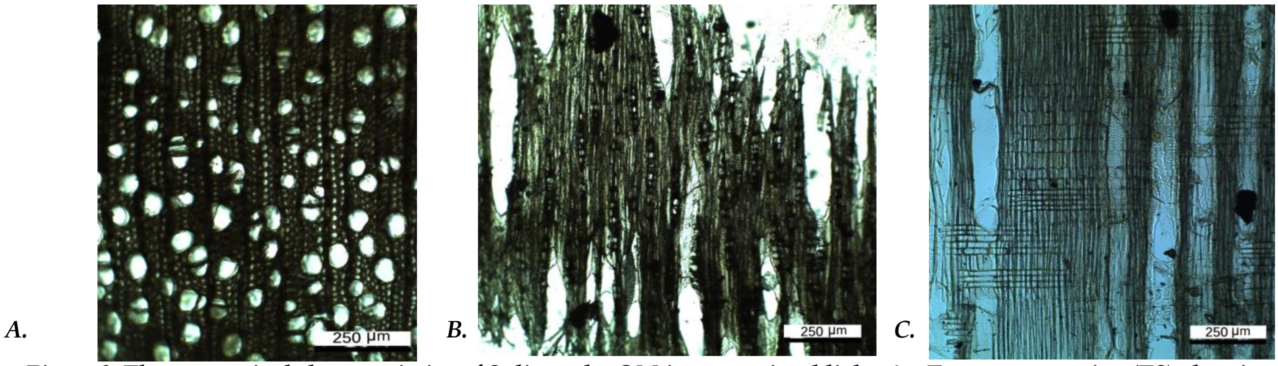


Figure 8. The anatomical characteristics of Salix sp. by OM in transmitted light: A - Transverse section (TS) showing growth ring boundaries distinct by the difference in vessel size between latewood and early wood, wood semi-ring porous. Vessels solitary or in radial multiple are consisted of 2-4 elements, axial parenchyma scanty paratracheal. ; B - Tangential section (TLS) showing rays exclusively uniserate. ; C – Radial section (RLS), simple perforation plates, intervessel pits alternate, fibers with simple to minutely bordered pits (libriform fibers), body ray cells procumbent with one row of square marginal cells (Crivellaro et al,2013; Wheeler,1989).

3.5. *Identification of Insects*

Insects are the most important and most frequently found animal pests attacking wood. The most common wood-destroying insects belong to the orders coleopteran (beetles) and isopteran (termites) (Unger, 2001). Two types of insects were identified. The first one is cigarette beetle *(Lasioderma serricorne)* depending on diagnostic morphology: Adults are 1/10 inch long (2-3 mm), they have an oval shape, and they are reddish-brown in color (Blyth, 1992). Larval feeding causes direct damage to foodstuffs and non-food items. These products are contaminated by the presence of beetles, larvae, pupae, cocoons, fecal material, and insect parts (Figure 9) (Jacobes, 2013).

Figure 9. Cigarette beetle (Lasioderma serricorne)

The second insect was identified as spider beetle (*Gibbium psylloid*) depending on diagnostic morphology: posterior margin of antennal fosse strongly produced laterally. The pubescence of the head and first antennal segment also differs: the setae near the antennal fosse on the top of the head are scale-like, the first antennal segment bears predominantly scale-like setae (Belles, 1989). These species are common in archaeological field and were mentioned by several studies. The spider beetle was found in the mummies of the two brothers, which are dated to the early middle kingdom period and likewise came from middle Egypt (David, 1978). The beetles are flightless, and have become widely distributed as a result of accidental transport by trade (Constantine, 1994).This species was also noted in the Tut ankh amun material which was one of the pests that were recovered from the Roman fort at mons claudianus in the eastern desert (Panagiotakopulu et al, 1997). Although the predominant species at Amarna today is G.aeqinoctiale, the large numbers of fossil specimens from Pharaonic Amarna are *G. Psylloides* (Figure10) (Panagio- takopulu, 2001).

Figure 10. Spider beetle (Gibbium psylloides)

3.6. Identification of vegetable ropes

3.6.1 Compound light microscope

Vegetable fibers are identified as linen (Figure 11), salient characteristics used for identification. The ultimate fiber has thick walls and a small lumen. Along the length of the fiber are transverse dislocations, which are called cross-thatches or nodes. The width is usually constant throughout the length of the fiber (Lou, 1990)**.**

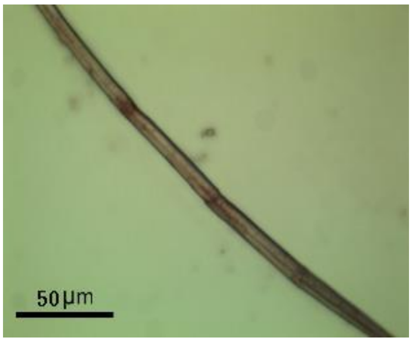


Figure 11. linen under compound light microscope

3.6.2. Fourier Transformed Infrared Spectroscopy

Fourier transform infrared spectroscopy analysis indicates that the vegetable ropes are linen based on characteristic absorption bands: C-H stretching bands 2916 and 2850 cm^{-1}, C-C stretching band 1627 cm^{-1}, C-H bending bands 1429 and 1371 cm^{-1} and O-H stretching band 3404 cm-1,FTIR was very effective to assess the vegetable ropes degradation rates by comparison with undecay sample, the prominent change which shows that the linen fibers have degraded can be seen by the spectra in the range of 1400 cm^{-1} to 1650 cm^{-1}, here an decrease in the intensities of the spectrum between samples has been noticed. It represents that the initial functional group that was present in the original sample has been degraded (Hulleman, 1994). the spectra of cellulose show decrease of bands particularly at 1372 cm^{-1}, 1336 cm^{-1}, 1313 cm^{-1}, 1280 cm^{-1}, 1160 cm^{-1} and 1105 cm^{-1}, when moving from high crystalline to amorphous cellulose, which means that the sample is degraded, also two intensive bands with maxima at 2850 and 2918 cm^{-1} are attributed to deformation vibrations of C-H groups in methyl and methylene groups [CH_3, CH_2, CH_2-OH] belonging to cellulose as well as to lignin (Hulleman, 1994) (Figure 12):

3.7. Identification of red pigment

3.7.1 Identification by Using XRD

A lot of red pigment minerals were found inside the scribe box, XRD analysis indicated that Hematite (Fe_2O_3) is responsible for red pigment. Red ochre used from the 5th dynasty till the roman times (Less, 2001). It was created by Egyptian artisans by using naturally oxidized iron and red ochre, it was the color of the desert and of the destructive god Seth, who impersonated the Evil, and Writers of Egyptian papyri used a special red ink for nasty words (Figure 13) (Noemi et al, 2010).

3.7.2. Identification by using XRF

Scribe box was completely coated with red pigment, XRF results revealed the presence of Fe, As main element, suggesting the use of hematite as pigment. Maybe hematite minerals that were found inside box also used to coat the box, besides, using in writing (Figure 14).

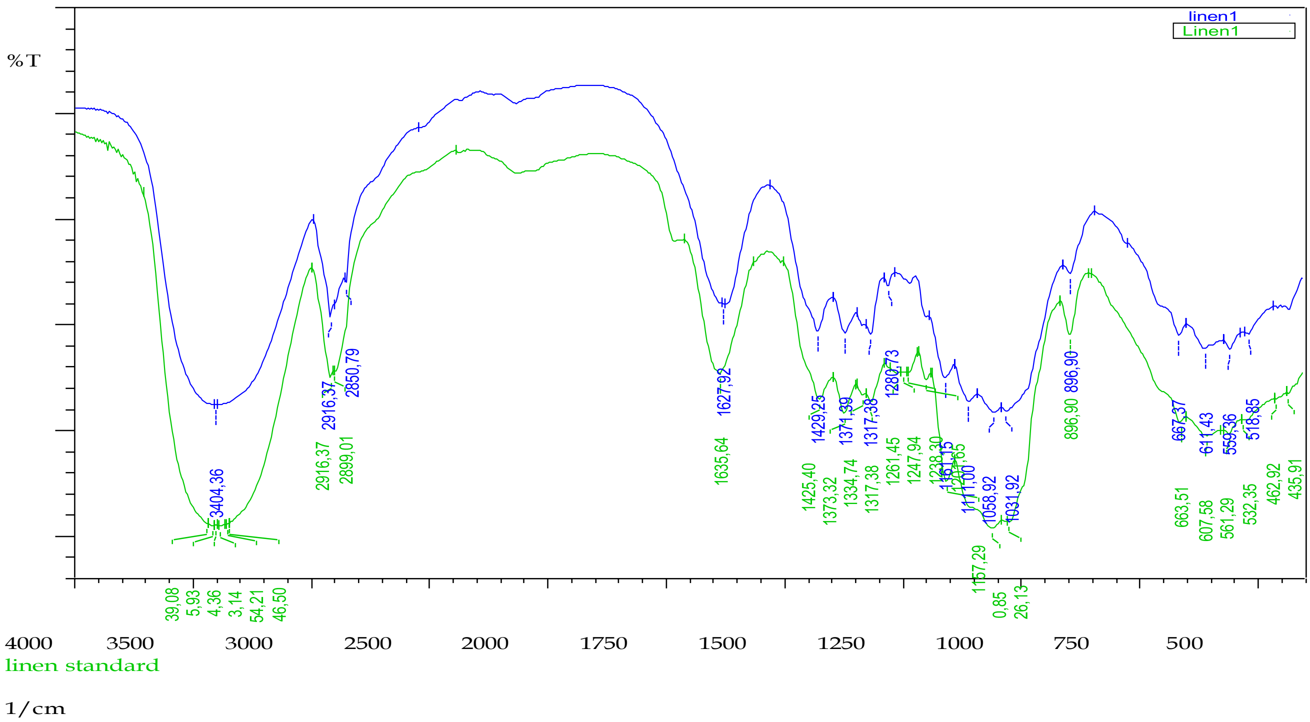


Figure 12. comparison between degraded linen and non decayed sample

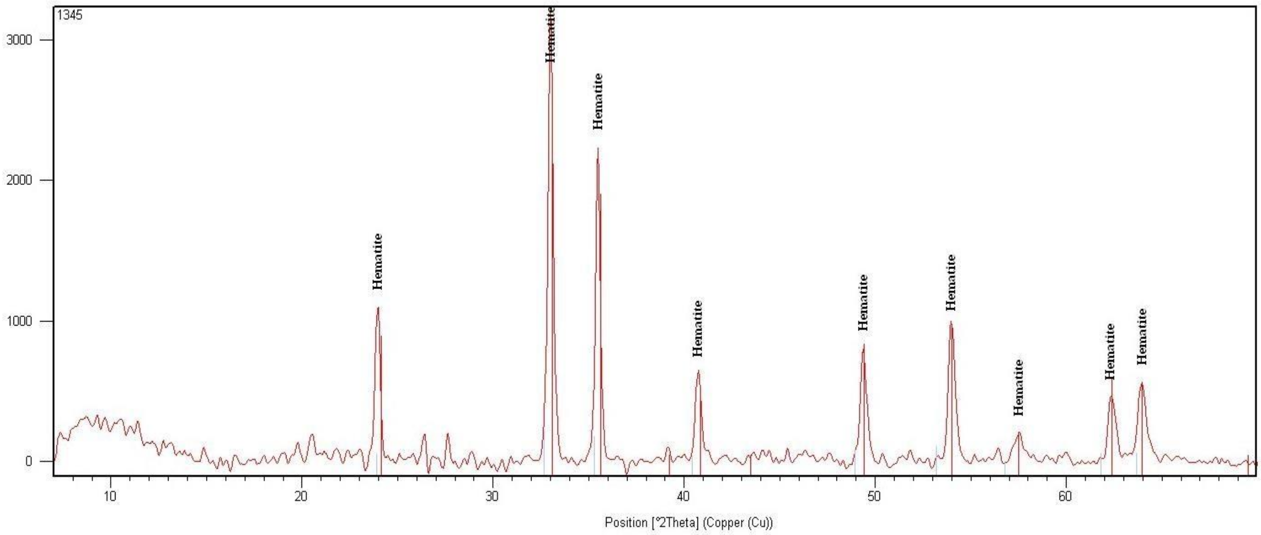


Figure 13. XRD analysis of red pigment

3.7.2. Identification of previous adhesive material

FTIR indicates that the previous adhesive material is cellulose nitrate. This indication based on characteristic absorption bands: O-H stretching band 3415 cm^{-1}, C-H stretching bands 2900 cm^{-1}, N-O stretching band 1653 cm^{-1}, N-O stretching band1278 cm^{-1}, C-H bending bands 1382 and 1415 cm^{-1}, C-O bending bands 1026,1066,1116 and 1159 cm^{-1}, N-O bending band 839 cm^{-1}. Cellulose nitrate was first made as a substitute for ivory (Michele et al, 1989), the Canadian conservation institute (CCI) has put cellulose nitrate on its list of materials that should not be used for conservation applications under any conditions (Selwitz,1988), and maybe this adhesive was applied during excavation (Figure 15).

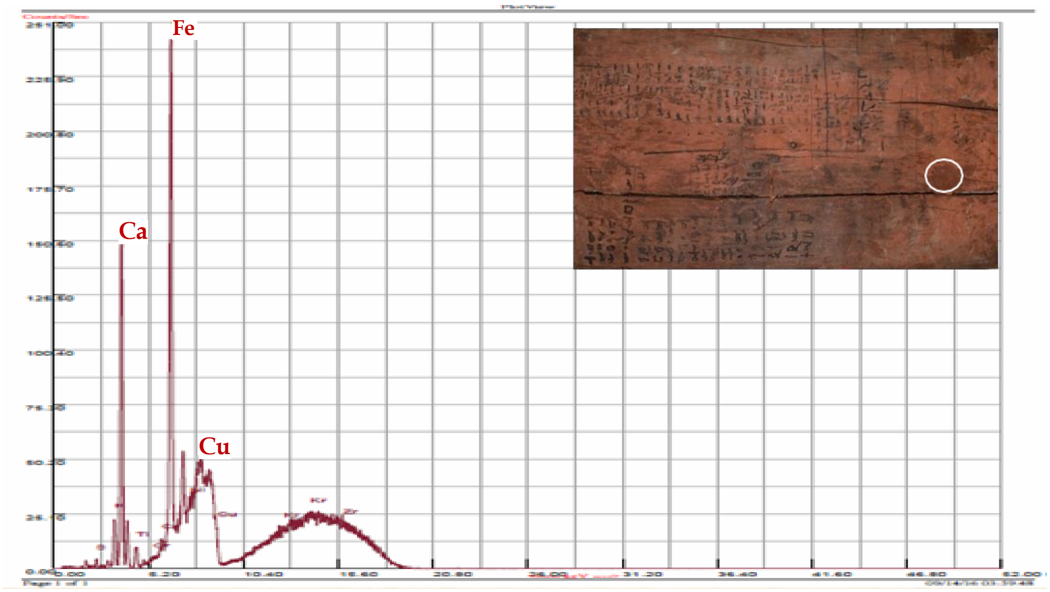


Figure 14. XRF analysis of Red pigment

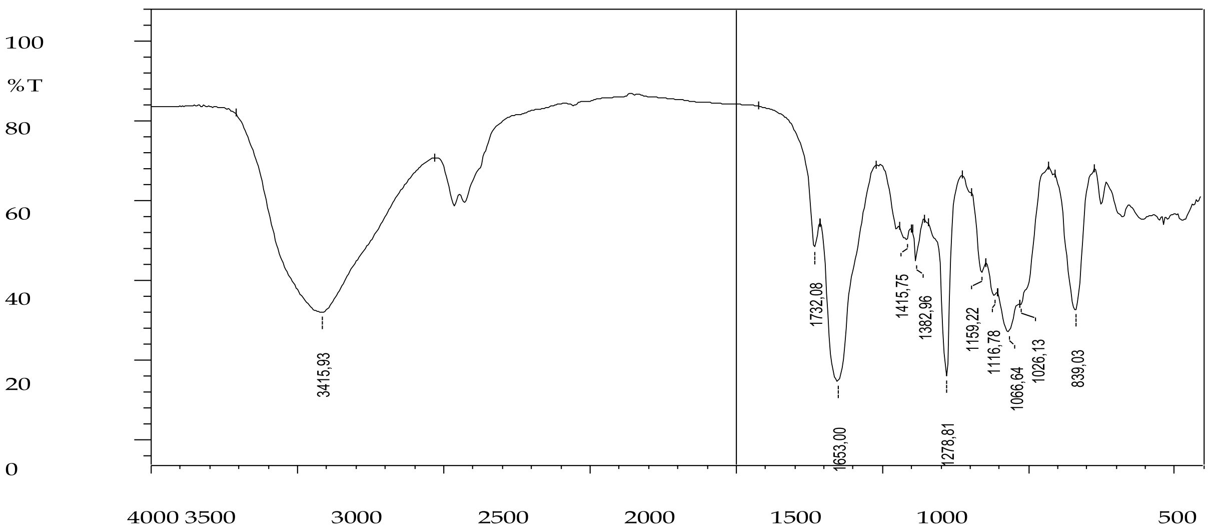


Figure 15. FTIR analysis of Cellulose Nitrate

4. TREATMENT AND CONSERVATION

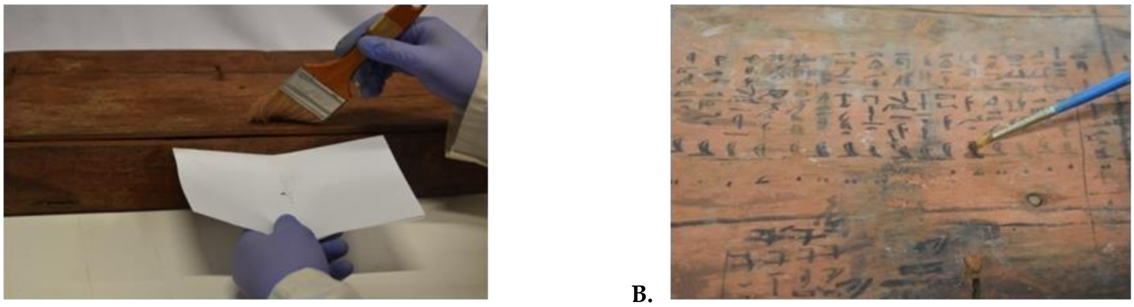
The main purpose of conservation is to preserve art and other artifacts in such a condition that coming generations may experience them and study their value therefore, several processes for treating and conserving the studied box were employed as soon as it was transported to the wood laboratory of the grand Egyptian museum–conservation center (GEM-CC), including cleaning, consolidating of friable pigments and writings, removal of previous adhesive and reassembly.

4.1. Surface Cleaning

As this box had been restored in non suitable conditions, fine dust was found over the surfaces of the box, loose dust was removed by gentle brushing with fine brushes (Figure 16A) (Johnson et al,1995; Nabil et al, 2013).

4.2. Consolidation of Friable pigments

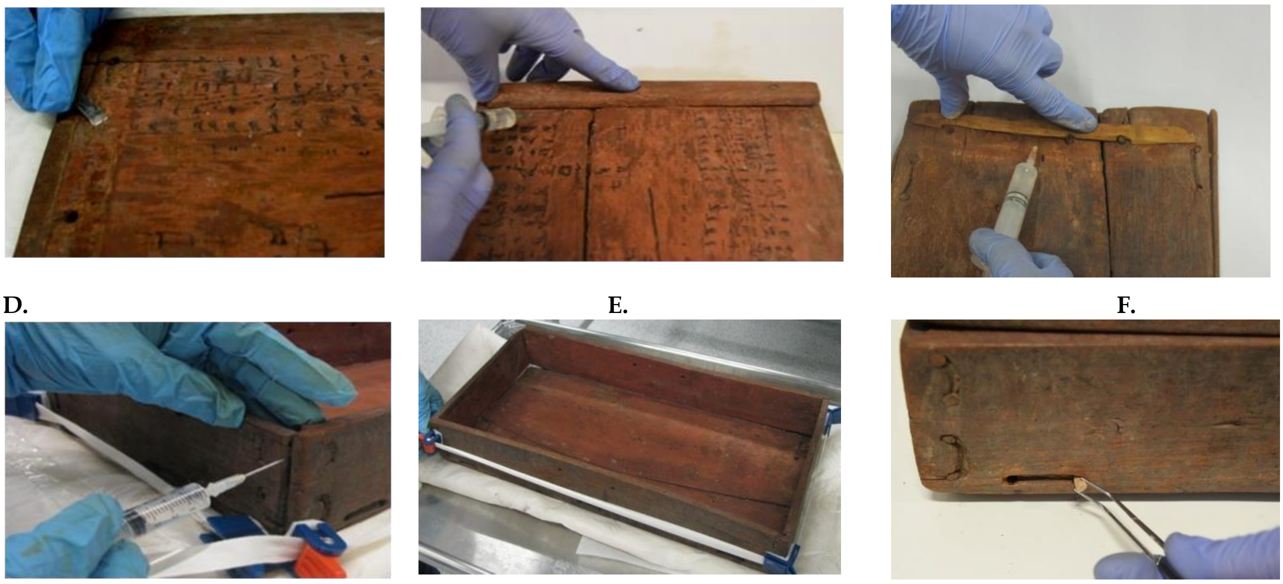
The ancient Egyptian writings and the red pigment that coated the box were friable, the efficiency of the treatment depends on the depth achieved, the nature of the product employed and its permanence on the cells and cell walls of wood (Lionetto et al, 2012; Hassan, 2009), consolidation with 1% Klucel G in Ethanol by using fine brushes was satisfied to consolidate friable pigments (Figure 16 B).



A. B.

Fig. 16. Treatment processes. mechanical cleaning, B. consolidation of friable pigments.

A. B. C.

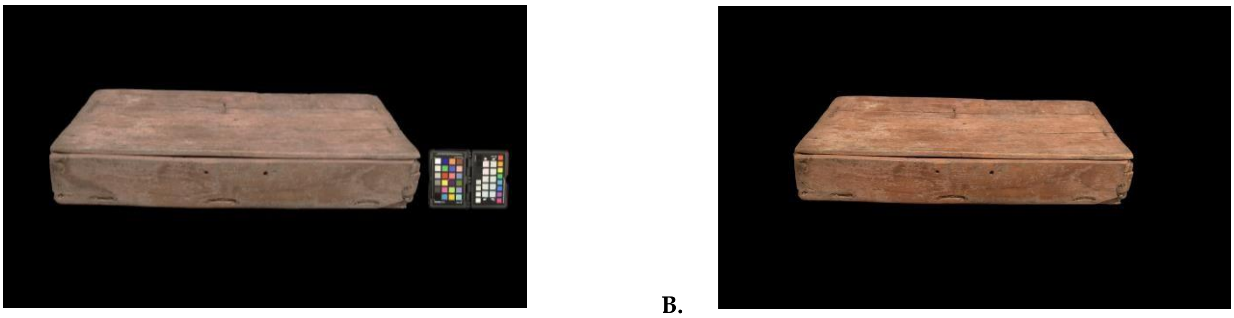


D. E. F.

Fig 17 A: mechanical cleaning for previous adhesive, B-C: adhered missing wooden rails in the original position, D: adhered box corners, E: Clamping, F: new dowels from white wood

4.3. Reassembling separated panels and wooden rails

FTIR analysis proved that adhesive used in previous restoration for assembling the wooden rails is cellulose nitrate. In order to reassembling lid wooden rail in its original position, mechanical cleaning and acetone were used to assess the solubility of the previous adhesive material (Figure 17A). B-72 (40% W/V in acetone is used in high accuracy to re-adhere the separated wooden rails at the lid and the outside bottom of the scribe box to the original position (Figure 17B). The box structure was unstable due to missing in several dowels and vegetable ropes. New dowels from urban white wood (*Picea sp*) (Figure 17D), and Paraloid B-72 (40% W/V) dissolved in acetone, besides clamping are used for re- assembly of the components of scribe box (Figures 17 E-F).



A. B.

Fig. 18. The scribe box before conservation, B. after conservation

5. CONCLUSION

The scribe box studied here (GEM No: 3682) dating back to old kingdom from Egyptian museum storage, consists of lid and body, was analyzed and subjected to deep restoring. Heretic writings of a funerary text found on the inside face of the lid. Deterioration aspects, including decay of vegetable ropes, missing wooden rails and dowels in the lid and body, separated wooden rails, led to non-stable condition of scribe box. 3D program produced a clear documentation of the wooden jointing techniques (half lap joint and edge joint). Using infrared reflectance transmission imaging (RTI-IR) improved the vision of the hidden inscriptions on the lid and identified their thickness. The materials were studied by optical and stereo microscope while their composition was determined by XRD, XRF and FTIR. Based on the results of the analyses, the previous adhesive was cellulose nitrate, hematite is responsible for the red pigment, and vegetable ropes are identified as linen. Examination results by optical microscope confirmed that the wood species of panels and dowels is acacia (*acacia nilotica*), while the bottom wooden rails is willow (*Salix sp*). Insects were identified as cigarette beetle (*Lasioderma serricorne*) and spider beetle (*Gibbium psylloides*). The materials and methods that had been applied were extremely effective for stability and reinforcement to the scribe box without harmfulness on the original materials. The box was successfully conserved and ready to display or storage in the Grand Egyptian Museum.

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