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# A DATING APPROACH OF A REFUNDABLE WOODEN EGYPTIAN COFFIN LID

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## ABSTRACT

In the Police seizures museum, Citadel, Egypt, there are large numbers of the refundable objects, a lot of them undated. So, this study focuses on dating a fragment of a refundable wooden Egyptian coffin lid based on its technology and typology through multi-analytical techniques. The coffin lid was examined by visual investigation, optical microscope, Scanning electron microscope (SEM) and EDAX, FTIR spectroscopy and X-ray diffraction. These investigations were carried on to identify the used wood, preparation layers, pigments and modern interventions. With the use of this information we tried to date this piece in accordance to the previous studies concerned with the coffin construction techniques through ages. The results showed that the stratigraphy of this coffin lid corresponds to the stratigraphy of the yellow coffins, which appeared at the 18th Dynasty (1575-1307 BC) and ending suddenly at the first half of twenty-two Dynasty (~945-840 BC), according to general similarities of shape, structure and coloring

**KEYWORDS: coffin lid, refundable, SEM-EDX, XRD, FTIR**

## 1. INTRODUCTION

The wooden coffin lid belongs to the Police seizures museum, Citadel, Egypt, number 1182, case number 1612. There is no record as to where it was found and stolen from, but it entered and stored in the museum 1992 AD, after arresting the thieves. Unfortunately, it was sawn off just below the hair and above the hands. So, it is reasonable to assume that to ease its carrying and smuggling. Furthermore, it is probable that the bottom part of the lid did not contain any decoration (Narkiss and wellman, 1995). It was assumed that the owner of this coffin is a man, since the wig is so simple and didn't show any of the hair details.

This object is a fragment of a coffin lid. This lid was anthropoid in shape, being about 44 cm long and 43 cm at its widest point, with side walls approximately 15.3cm deep. It constructed of wood planks joined at edges and coated with preparation layers that painted with a yellow background (Fig. 1 a, b). The wig executed in black and ended with two lines which contain a yellow space between them and a green coloured band (Fig. 2). A broad collar is seen beneath the wig and extended to the shoulders decorated with geometric patterns, which outlined with black pigment. On the left side of the lid at the ending of the collar a drawing of a falcon is presented. Black cross stripes depicted around the shoulders (Fig. 3 a, b).

Taylor (1989) mentioned that there are certain elements and changes in the coffins' designs enable us to use stylistic techniques as a dating method. For example, the size of collar depicted about the neck of the anthropoid coffin, as it increased to cover the arms around 1000 BC. Also, the space that was occupied by the winged Nut has changed to accommodate a number of deities.

*Figure 1. The refundable fragment of the coffin lid; a. the front side, b. the backside, show the shape and stratigraphic structure of the coffin lid.*

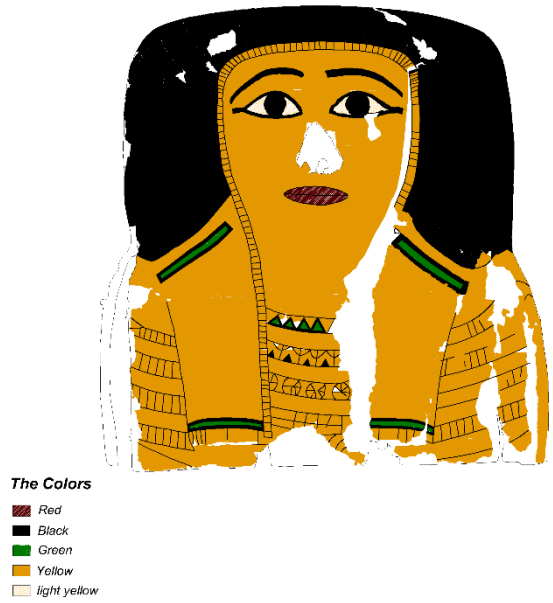


*Figure 2. show the palette of the pigments used in the coffin lid.*

*Figure 3 (a, b). show the details of painted designs from both sides.*

The painted surface of the lid has experienced stains from adhesives and a white material, coming from a previous treatment, as well as cracking and separation between planks and in the painted preparation layers. Also, general weakening and losing parts of the wood took place. The painted preparation layers of the lid exhibited detachment, flaking and lose some parts. It is reasonable to assume that all these aspects resulting from the sawn process and smuggling procedures which affected the integrity of the stolen piece.

Mainly, the information about the ancient Egyptian coffins is based on the many examples that were found in different locations in Egypt (Eladany, 2011; Stein and Lacovara, 2010; Zidan et al., 2016) examined and compared the preparation layers on the ancient Egyptian coffins from the Middle Kingdom (2050-1710 BC) to the Roman Period and noticed that there are some technical choices in coffin construction and decoration appeared to prevail within a certain period [see NOTE 1].

Additionally, Egyptian coffins have been the subject of much recent investigations to reveal their construction techniques and painting materials (Watkinson and Brown, 1995; Elston, 1995; Amenta, 2014; Bracci et al. 2015; Abdrabou et al. 2017; Moustafa et al., 2017).

The aim of this research is dating the refundable coffin lid according to its stratigraphic structure and its typology. Different analytical methods were used to examine and identify the components of the various layers from which the lid constructed.

## 2. MATERIALS AND METHODS

### *2.1- Sampling*

The samples were taken from the different wood planks, wooden dowels, the painted preparation layers and the accumulated stains of materials used in the previous restoration.

### *2.2. Investigation and Analytical Methods*

#### 2.2.1- Light Microscope

For light microscopic study, semi-thin sections of samples were cut into three directions: transverse section (TS), tangential longitudinal section (TLS) and radial longitudinal section (RLS) with a glass knife using a microtome. Stained sections were observed and photographed using Optika Microscopy (Italy) equipped with Optika B 9 Digital Camera.

#### 2.2.2- Environmental Scanning Electron Microscope (ESEM) and EDX

SEM study was performed to study and evaluate the morphological changes in the wooden samples by fixing small pieces of an appropriate size on aluminum stubs with double-sided cellophane tape. The samples were examined using a Quanta250 FEG SEM. In addition, the elemental composition of the preparation layers and the white materials that covered the painted surface from earlier treatment were analyzed using an EDX unit attached to SEM.

#### 2.2.3. Fourier Transform Infra-Red Spectroscopy (FTIR)

FTIR was used to identify the medium which used in the painted preparation layers, to monitor the chemical characterization and changes that occurred in the wood, and to study the adhesive material used in previous restoration. So, samples were analyzed with a FTIR spectrometer (Model 6100 Jasco, Japan). Spectra were obtained in the transmission mode with TGS detector using KBr method and represent (2mm/Sec) co -added scans at the spectral region ranging from 400 $cm^{-1}$ to 4000$cm^{-1}$.

#### 2.2.4. X-Ray diffraction (XRD)

The mineral composition and its percentage of the preparation layers, and the paints applied on its surface, were determined using a Philips X-ray diffractmeter, type PW 1480, giving 40 kV Cu Ka radiation at 25 mA, Netherland and a program analysis: PDF4 2015 + Match2. This procedure was done at Conservation Department, Faculty of Archaeology, Cairo University.

## 3. RESULTS

### *3.1. Microscopic Examination*

#### 3.1.1. Light Microscope

Microscopic investigation indicated that the wood used in the upper board (Fig. 4), in the side board (Fig. 5) and in the middle board (Fig. 6) was Sycamore fig (*Ficus sycomorus*). 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 as seen in TS. Rays of two distinct sizes; 1-4 seriate and larger rays commonly 5 to 12 seriate up to 20 high, and Prismatic crystals in non-chambered axial parenchyma cells ,and some lacticifers observed in rays as seen in TLS. Heterocellular rays with square and upright cells only on marginal rows and strongly procumbent central cells; simple perforation plates and solitary prismatic crystals present in upright and / or square ray cells as seen in RLS (Wheeler et al., 1989; Crivellaro and Schweingruber, 2013; Cartwright et al. 2011).

As for the wood of the dowels used to join the coffin boards together was identified as ***acacia nilotica.***

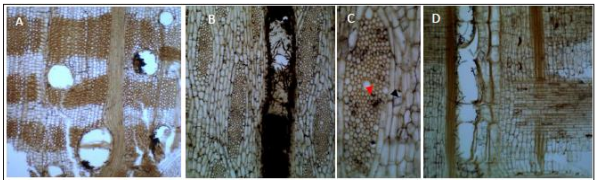


***Figure 4. Light microscope images of A - Transverse section (TS); B - Tangential section (TLS); C laticifers in rays; D- Radial section (TLS) of sycomore wood (Ficus sycomorus) taken from the coffin's upper board***

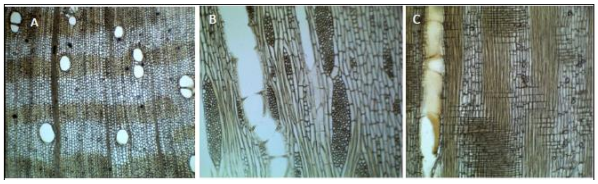


***Figure 5. Light microscope images of A - Transverse section (TS); B - Tangential section (TLS); C- Radial section (TLS) of sycomore wood (Ficus sycomorus) taken from the coffin's side board.***

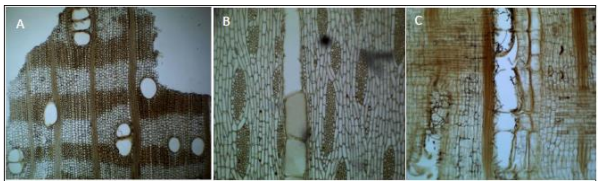

*Figure 6. Light microscope images of A - Transverse section (TS); B - Tangential section (TLS); C - Radial section (TLS) of sycomore wood (Ficus sycomorus) taken from the coffin's middle board.*

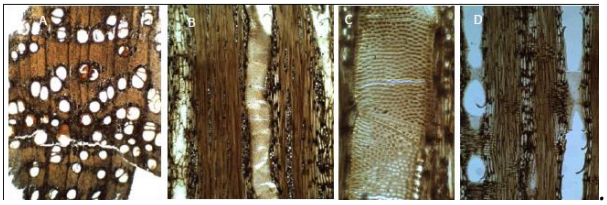

*Figure 7. Light microscope images of A - Transverse section (TS); B - Tangential section (TLS); C- detail of Tangential section (TLS); D- Radial section (TLS) of Acacia.nilotica taken from dowels*

The diagnostic characteristics used to identify *acacia nilotica* were wood diffuse porous; vessels in multiples (2–4) sometimes solitary, vessel outline rounded; paratracheal axial parenchyma vasicentric, aliform and confluent as seen in TS, multiseriate rays 2–4 seriate, simple perforation plates and intervessel pits alternate as seen in TLS; homocellular rays with procumbent cells; some prismatic crystals present in chambered axial parenchyma cells as seen in RLS (Wheeler et al., 1989).

### 3.1.2. Environmental Scanning Electron Microscope (ESEM) and EDX

SEM micrographs show accumulation of the preparation layers particles on the wood tissue and their penetration within the wood cells. Also, the prismatic crystals in parenchyma cells which are characteristic to *Ficus sycomorus L.* (Waly, 1994) appeared clearly in fig. 8 (a, b, c, d). Additionally, deterioration of cells due to these accumulations can be clearly seen in fig. 8 (e, f), as the samples exhibited cracks, fractures and uneven erosion of the cell wall layers in some regions of the wood tissue.
The EDX results confirm that the elemental composition of the preparation layers contains Sulphur (S), calcium (Ca), carbon (C), silicon (Si), sodium (Na) and chloride (Cl) elements (fig. 9a). Also, the results of the white material used in earlier treatment show a high percentage of Sulphur and calcium (Fig. 9b).

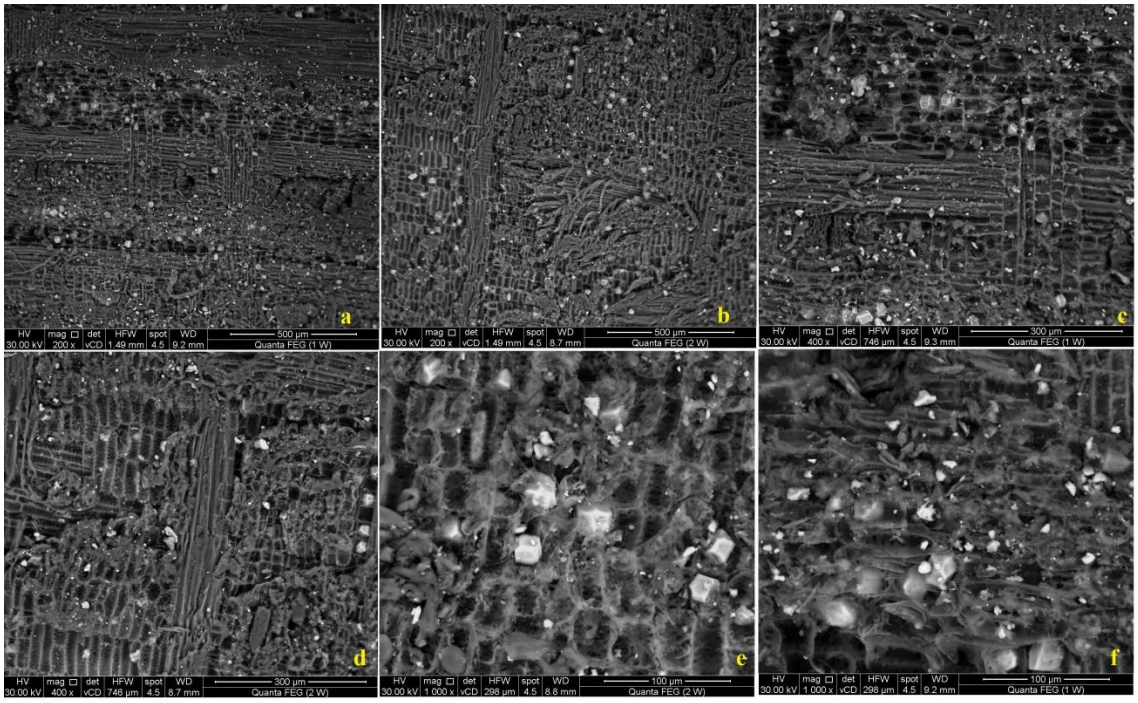

*Figure 8. SEM micrographs show accumulation of the preparation layers particles on the wood tissue and their penetration within the wood cells (a, b, c, d). Also, the prismatic crystals in parenchyma cells and deterioration of cells due to these accumulations can be seen (e, f).*

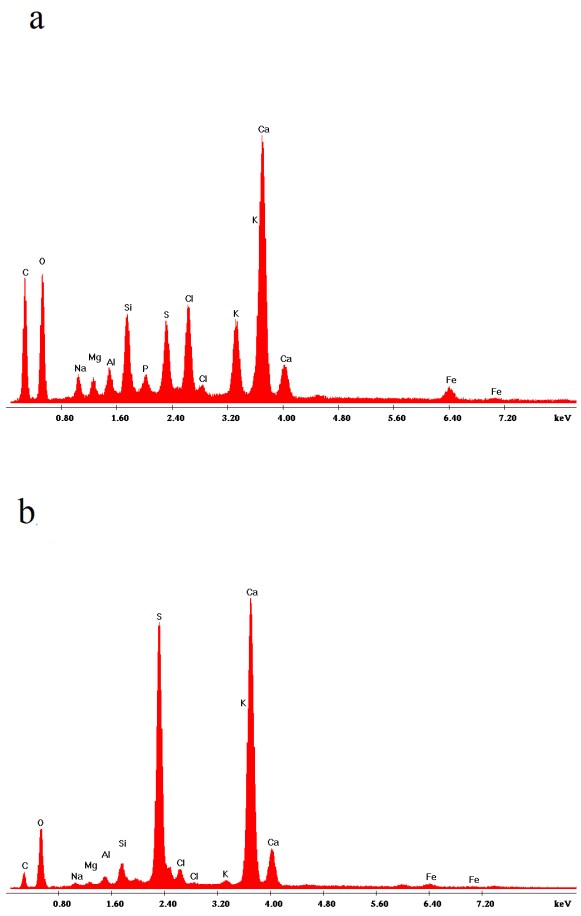


*Figure 9. EDX patterns: (a) the preparation layer, (b) the white material that used in previous restoration.*

### 3.2. *Fourier Transform Infra-Red Spectroscopy (FTIR)*

FTIR spectrum of the painted preparation layer (Fig.10a) shows presence of bands corresponding to the stretching frequencies of sulphate which indicative of the presence of gypsum $CaSO_4\,2H_2O$ at 3531-3395 $cm^{-1}$ (Perdikatsis and Brecoulaki 2003; Schilling, et al., 2004; Afifi and Abd El Fatah, 2011). Furthermore, the characteristic bands of animal glue which is possibly used as a binder in these layers can be seen at 1620 $cm^{-1}$ due to C=O stretching absorption (amide I) and 1550 $cm^{-1}$ due to C-N-H bending band (Amide II). The results of wood samples of the coffin lid (Fig. 10b) indicate disappearing the band of unconjugated C=O stretching around (1730 $cm^{-1}$) which can be explained by hemicellulose decay and the band at 1605 representing lignin. Also, presence of the band at 1645$cm^{-1}$ of conjugated C=O due to oxidation of cellulose. The adhesive material that was used in earlier intervention (fig. 10c), was paraloid B72 as seen in the FTIR spectra because the existence of its characteristic bands at 2934-2861 $cm^{-1}$, 1727 $cm^{-1}$, 1370-1430 $cm^{-1}$ and 1020-1228 $cm^{-1}$ (Derrick et al. 1999).

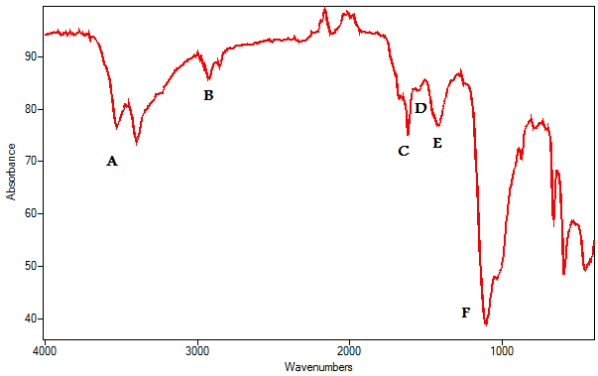


*Figure 10a. FTIR spectra of the painted preparation layer.*

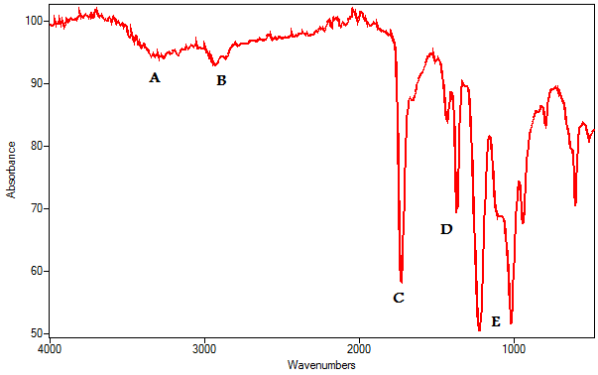


*Figure 10b. FTIR spectra of the wood sample.*

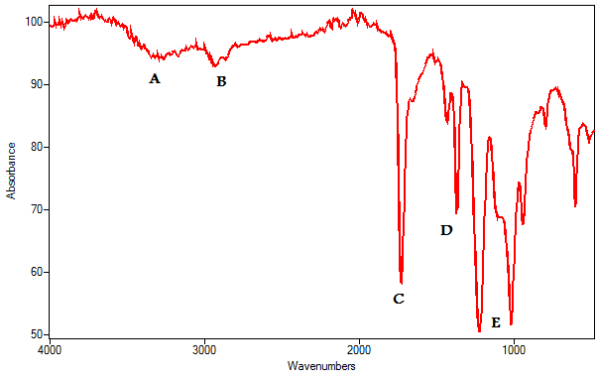


*Figure 10c. FTIR spectra of the adhesive material that have been used in previous restoration.*

### 3.3. *X-Ray Diffraction*

The XRD results showed that the gesso layer that covered the wood surface in the coffin lid was composed primarily of calcium carbonate (calcite) mixed with low percentage of calcium sulfate. Also, according to the results, the yellow color, that represent the face and body color, was composed of Goethite (Iron Oxide Hydroxide, FeO(OH)) (Fig.11a ), the black color that represent the hair color was composed of Graphite (Carbon, C) (Fig.11b), and the green color, that was found on some parts of the necklace, was composed of Greenalite (Iron Silicate

Hydroxide, $Fe_6Si_4O_{10}(OH)^8$) (Fig. 11c ). Additionally, Figs (11d and 11e) have showon the chemical composition of the mud layer that was used to cover the wood planks from outside and underside of the coffin lid, as well as to fill the gaps between boards. The mud layer was composed mainly of clay minerals (Quartz and Albite) with low percentage of calcite with presence of halite.

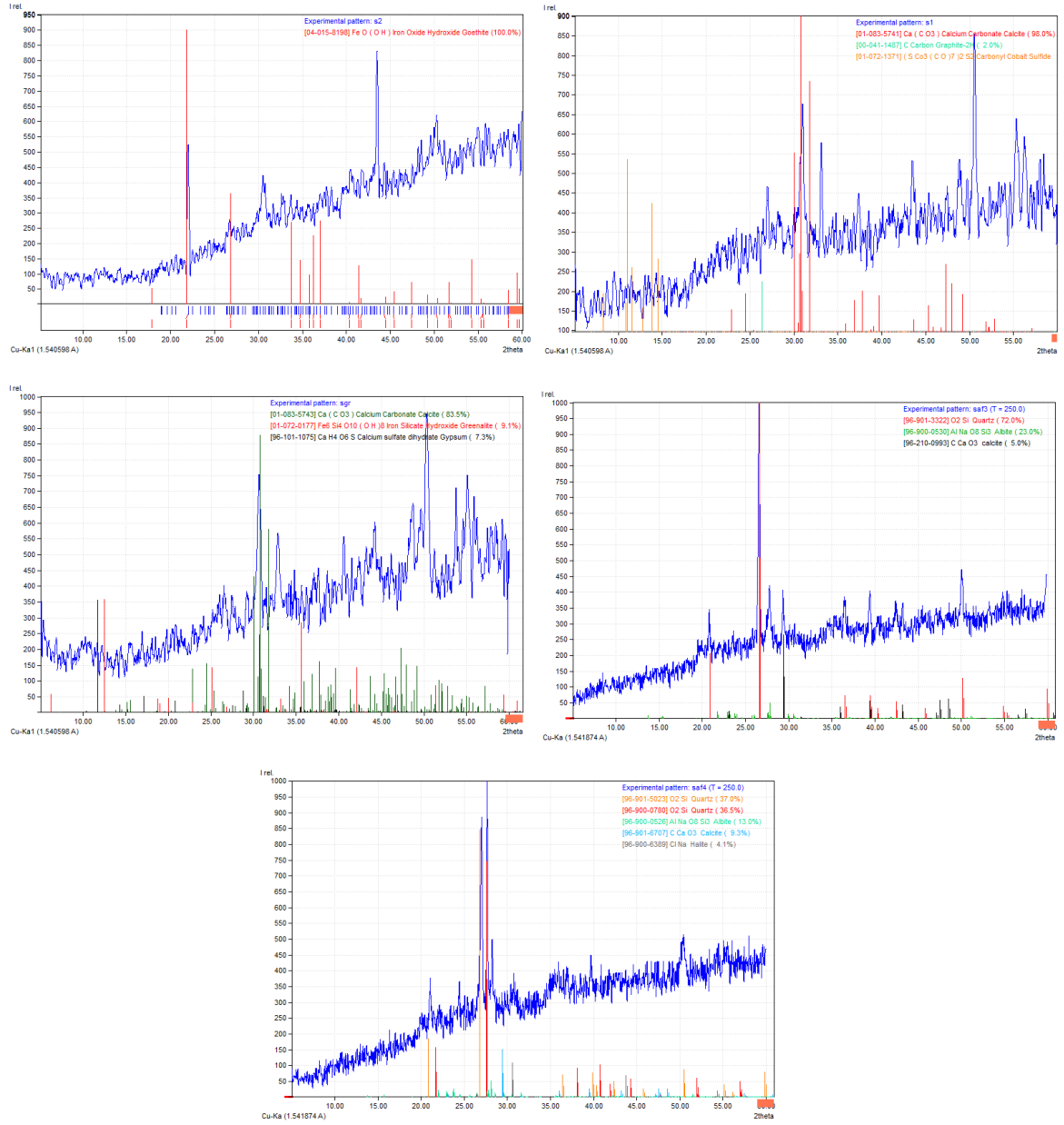


*Figure 11. X-ray diffraction patters of; a. the yellow color, b. the black color, c. the black color, d. the inner layer of mud, e. the mud layer between boards.*

## 4. DISCUSSION & CONCLUSION

Concerning the shape, the coffin lid belongs to the anthropoid yellow type characteristic to the period from 18th Dynasty to the first half of the 22nd Dynasty. Also, the anthropoid coffin was the main style of coffins during the 21st Dynasty, since it was a replacement to the mummy in case it was damaged as considered by the ancient Egyptians (Taylor 2001). Added to that the black cross strips, which representing the leather mummy braces on the coffin lid around the shoulder of the mummy, considered one of the important developments that took place towards the end of the 21st Dynasty (Taylor, 1989.

The materials and the technology of the coffin lid were investigated and were found to be consistent with documented ancient Egyptian polychrome coffins dates to 21st Dynasty (Watkinson and Brown, 1995; Stein and Lacovara, 2010; Eladany, 2011; Amenta, 2014). According to the scientific investigation results the coffin lid constructed of

wood planks that identified as *Ficus sycomorus L.* and doweled at edges with *Acacia nilotica*. Also, these wood planks are subjected to deterioration may be due to the mechanical effect of preparation layer's weight (Hamed et al., 2013, or the chemical attack of them on the wood surface (El Hadidi and Hamed, 2017).

The coffin lid was coated from inside and outside with two preparation layers; the first one a preparation layer composed of mud mixture containing calcite which was applied on the entire surface of the lid. The second one was a fine layer composed of calcium carbonate (calcite) with some calcium sulphate and animal glue as a binder medium. Tempera technique was applied in this lid with yellow background, that identified as Goethite, which characteristic to *yellow coffins* (Taylor, 1989; Eladany, 2011; Amenta, 2014) as well as, the designs executed in black and green.

Investigation of some earlier interventions, aimed at repair of lid's damage, revealed the use of gypsum to compensate lost areas in the preparation layer, and paraloid B72 in consolidation the lid. These repairs were of low artistic and technical standards.

Limitation of this study was the great difficulty in dating the refundable coffin lid with scientific analytical methods as this piece was all what it was left of the lid and the available device of analyzing with Carbon 14 requires a relatively high weight of specimen. Also, we couldn't use the dendrochronology dating since there is no database to our local woods. So, the dating of this object depends on the typology and the stratigraphy of the coffin lid.

## NOTES

[1] 18th Dynasty: 1575-1307 BC; 19th Dynasty: 1307-1069 BC; 20th Dynasty: 1196-1069 BC; 21st Dynasty: 1069-945 BC; 22nd Dynasty: 945-720 BC.

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