

Original Article

REOPENING THE GOLDEN DOORS OF TUTANKHAMUN'S INNERMOST SHRINE

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Abstract:

With the death of Tutankhamun, the four shrines were neatly assembled in the king's burial chamber, enclosing and safeguarding the royal mummy. They remained there for centuries until the discovery of the tomb with its funerary furniture just over one hundred years ago. The four shrines, which were found intact, were transferred from the Valley of the Kings to the Egyptian Museum in Cairo (EMC). With the Grand Egyptian Museum (GEM) opening its doors to the public the gilded shrines will be among the masterpieces that will be exhibited during the opening of the museum. The challenges to transfer these shrines in their current condition led to the decision to carry out a detailed study of the shrines, so as to decide upon the best mode of action and the necessary precautions, prior to undergoing any conservation treatments and dismantling. This study aims to identify and document the interior structure and construction techniques of the wooden panels, ceiling, wooden tenons and copper tongues that join together the ceiling and panels, in addition to the materials used in gilding as a preliminary step before transferring the shrine to the Grand Egyptian Museum (GEM). Full scale documentation and examination were conducted using photography in visible and UV light, RTI, AutoCAD 2D, and digital light microscopy. X-Ray Radiography and Portable X-Ray Fluorescence Spectroscopy (PXRF), a nondestructive analysis, were also conducted and shed new light on joinery and gilding techniques. This comprehensive study has revealed some interesting facts about the shrine and reviewed it from a different perspective.

1. Introduction

One of the most eye-catching scenes at the Egyptian Museum in Tahrir was the magnificent corridor on the second floor, in which all four wooden shrines from the tomb of Tutankhamun were exhibited. How the shrines had been constructed and which materials were actually used was often asked by museum visitors, but rarely would they get a precise answer, because in the past no one really got the opportunity to study the shrines with nondestructive tools, yet it has been definitely confirmed in previous research that the main materials that had been used for making the shrine are wood, gilded gesso layer, and metal. It was a technique applied in the New Kingdom for the manufacture of artifacts for mem-

bers of the royal family. After the discovery of the tomb, Lucas did thorough investigations and chemical analysis to identify all the materials that had been used in the making of all the artifacts found inside the tomb of Tutankhamun. Photographs taken by Burton, which are available online, were used at the time of the excavation in the last century to document the shrines that had been kept sealed since the king's funeral and the process of their dismantlement inside the tomb. Additionally, Lucas did a lot of hand sketches in which he recorded the dimensions of the artifacts as they had been found in the tomb and after their disassembly into different parts. These thorough studies conducted in the late

1920's, have been very useful to scholars interested in studying ancient materials and technologies. Tutankhamun's innermost shrine (Carter number 239, JE 60668, GEM 16) had been mainly composed of four panels (north, east, south, west) and a ceiling. They were made of *wood, gilded gesso layer and metal.*

1.1. Wood

Wood was the main substrate or support, which was covered with textile, ground layer, and gold leaf. It was noted in previous publications that the timber of the shrines was remarkably heavy, and several references on its identification can confuse readers. For example, in one account on the outermost shrine it was noted that "the specimen examined was identified by Mr. Boodle of the Jodrell Laboratory of the Royal Botanic Gardens, Kew, as a piece of Oak. It was not possible to identify it specifically, but it was suggested at that time that it may be *Quercus cerris*, L., which may have been imported from Syria or the coast of Asia Minor" (Card/Transcription No.: 207-02) [1]. In Carter's book, it was mentioned that the shrines were made of 2.25-inch oak planking [2], yet in his notes TA A.i.3.23.1 that are available online he wrote, "The four shrines are made of cedar, oak and Christ's thorn wood. The planking employed varies from 9 to 25 cm wide, and from 3 to 12 cm in thickness; the panel boards from 2 to 25 cm in width and from 5.5 to 7.5 cm thick; in accordance with the size of the shrines" [3]. In the register of samples written by Lucas in the years between 1922 and 1939 it is noted that the 8 pieces that were identified from the shrine and pall frame consisted of *Cedrus* sp. and *Ziziphus mucronata*, and the possibility of oak was omitted (TAA_i_2_11_88&89) (TAA_i_2_11_94&95) [4,5]. Samples from the fourth inner shrine and coffin examined and identified by Waly under the microscope confirmed the fact that cedar wood had been used in addition to three more wood types:

- a. Cypress (*Cupressus sempervirens*) which had been covered with a gilding layer
- b. Oak (*Quercus ithaburensis*) which was taken from a tenon.
- c. Sidder (*Ziziphus spina-christi*) which was taken from a dowel [6].

1.2. Gilded gesso layer

A gesso layer, composed of calcium carbonate and an animal glue binder was used to adhere a linen textile layer to the wooden surface [7]. This inscribed gesso layer, that was sometimes covered with a layer of bole or a "shade of reddish-brown clay" was the main gilding substrate in the gilded shrines. The terms foil and leaf have been applied by rese-

archers to a variety of metal sheets with different thicknesses, compositions, and physical properties. Leaf has been used to describe thin sheet gold that is unable to support its own weight [8]. The most ancient document about gold foil or leaf mechanical forming was found in an Egyptian tomb from Saqqara, dated of 2500 BC [9], where a gold melting operation and a worker beating (or hammering?) gold with a round stone are depicted [10]. This technique appears to have been brought to its perfection in ancient Egypt as some authors report a leaf thickness varying between 14.1 μm to 19.5 μm and 23.1 μm to 47.9 μm in the gilded wood samples from one of the Tutankhamun coffins and shrines [7]. Another reference reports that a leaf thickness of 0.2 μm has been identified during the 18th dynasty (1550- 1300 BC) [10].

1.3. Metal

In addition to wood, which was the main construction material in the shrine, copper was identified by Lucas in several parts, each of which had a different design and purpose.

- a. The metal band round the base of the shrine (copper binding). As noted in previous literature all four shrines are edged with a U-shaped binding "to protect their footing. This has been formed individually around each body element and is a sure indication of wood segment division". "The metal was covered with a dark green coating which suggested that it had been painted (especially in view of the discovery of a broad line painted in a similar dark green around the base of the stone sarcophagus)" [11].
- b. Tenons/tongues made of copper; the roof section which includes a cornice and torus moulding was joined to the four horizontal under beams, with alternating wooden tenons and copper tongues.
- c. Pivot hinges; the doors moved on pivots, one rising upward and fitting into a socket in the lintel and the other going downward and revolving in a recess in the threshold [2]. Fortunately, the dismantling of the shrine made it possible to study the fourth innermost shrine and to partially understand the technology behind the making of the shrines. In the current study the main aim is to shed new light on the previously documented findings using nondestructive investigation and analyses, which were conducted as a preliminary study before conservation, dismantling and transfer of the shrine from the Egyptian museum in Tahrir to the Grand Egyptian Museum in Giza.
- d. Silver coated copper handles of staple-like form, which were used for seal attachment and opening doors [2].

2. Materials and Methods

During the preparatory work of dismantling the innermost shrine (Carter number 239, JE 60668) investigation and non-destructive testing were carried out as follows: A digital DSLR full frame camera Nikon D810 (36.3 MP) was used for all photographic documentation. AF-S NIKKOR 24-70 mm f/2.8E ED VR lens was used for general images of the shrine. While AF-S Micro NIKKOR 60mm F2.8G ED lens was used for detailed images. Two studio flash lighting sources (Elinchrom D-Lite RX4, 400 Ws) were covered with two large Portalite soft-boxes as light modifiers. White boards were used to reflect some light towards the lower part of the shrine's outer sides. For detailed images, an external flashlight (Nikon SB-900) was attached to the top of the camera through the hot shoe. UV light was used to document previous conservation materials and a digital microscope USB S02, Cooling Tech 50X to 500X optical zoom was used to document details of the gilding materials. Reflectance transformation imaging (RTI) was performed using a Canon 5D mark III camera for RTI VIS with a Canon 50 mm f/1:2.8 AF lens. The shrine panels were photographed vertically with two shiny black spheres used as reflection targets and illuminated by a light source Canon Speedlite 580EX II Flash manually held in position. The camera was operated in fully manual mode with setting (ISO= 100 - Shutter speed 1/160 – F Number 11) and was tethered to a computer using live view mode. Forty-five photographs were taken with the same mode but with different light direction, always maintaining the same distance from the subject which was almost 3.5 times the size of the object photographed, creating an imaginary dome around it. For X-Ray Radiography the suitable distance between the GE Wireless Digital Detector DXR250C-W (16"x16") and the x-ray source (Radioflex 200sps - Rigaku Corporation) should be at least 150 cm, which was almost the width of the shrine, therefore it was decided to place the detector (flat panel) inside the shrine and the x-ray source outside the shrine. The detector was placed as close as possible to the examined surface to produce greater distinctness and clarity in the image, which was almost the actual size of the x-rayed part. There was an overlap of approx. 10 cm in every two adjacent images, which was necessary during editing using Photoshop. From the final image, it was possible to obtain an AutoCAD drawing with the wooden tenons and dowels included. The measurements settings were tube voltage 100kV and tube current 2.5mA. X-ray Fluorescence analysis was conducted using a portable EDXRF spectrometer (Elio Spectrometer, XGlab srl, Milan, Italy) which can detect elements from Si to U with a field of

analysis extending between 1 and 50 kV. The measurement settings used were the following: Time: 40 s, tube voltage: 40 kV, tube current: 20 μ A, target material: Rhodium, Sample to detector material: air.

3. Results

Wood, gesso, metal, and gilding layers had been primarily studied and identified back in the 1920's prior to the transfer of the shrine from the tomb to the museum in Cairo. The scientific findings of the traditional analytical techniques by Lucas and Scott, made it easy for scholars to understand how the shrine may have been constructed, and which materials had been used, yet, by conducting different nondestructive techniques, it was possible to identify in more detail the techniques applied in the shrine. Photographing gilded surfaces is always very challenging because of their highly reflective surface. Many trials were conducted before finally selecting and setting the best lighting sources, modifiers, and location to avoid the strong highlights reflections that cause improper overexposed images obscuring some of the surface details. The flashlight was always positioned to bounce indirect lighting towards the gilded surface of the shrine and was covered with a light diffuser to ensure wide, even, and soft lighting for the captured image details. By comparing the images taken of the gilded surface of the shrine using RTI, the application method of the gold leaf that was applied on the carved gesso layer which covered the wood and textile layers was noticeably variable. In some parts, the surface had not been well polished, therefore the curvatures presented a non-smooth surface of the preparation layer. The brush strokes used in the application of the final preparation layer were evident, while in other parts tool marks were present fig. (1).





Figure (1) RTI images of gilding layer; **a.** creases in gilding layer, **b.** circular protruding dowel, buckling of gesso layer and brush strokes in gilding layer, **c.** brush strokes, creasing in the tight areas of the bas-relief and the layers of the rough and fine coat of the gesso layer in the missing part of the left elbow.

Furthermore, it was possible to differentiate between manufacturing technique and deterioration aspects, such as the loss of binding media that had been used in the application of the gilded layer, which was clearly evident in the creases that were observed on the surface of gold. Additionally, with the aid of RTI imaging, a clear difference in the behavior between two severely affected converging areas becomes obvious, when compared with the adjacent area which was not affected in the same manner. Also the variation in the quality of gold leaf was clearly noted both in the RTI images and pictures taken in UV light fig. (2).



Figure (2) UV imaging of yellow and red gold inside the shrine

With the aid of a portable digital microscope the fine details of the clothing or inscriptions, which were either incised or punched into the bas relief of the gilded gesso layer using fine tools, fig. (3).



Figure (3) digital microscope images showing details of different tool marks that were used on the gold leaf to incise fine details.

The X-ray radiographs of the four corners of the shrine, in which the panels and corner posts were connected, and the joinery areas between the four sides and the ceiling clearly showed that the idea of alternating wooden tenons and metal tongues had been applied in all the paneling of the innermost shrine, whether it was applied for joining the wooden planks together with dowelled tenons, or for joining the ceiling to the sides. All the wooden tenons were buried inside the wooden planks, and the only visual evidence of their presence are the slightly protruding or elevated rounded parts in the finely decorated gilding layer as seen in the RTI image in fig. (1-b), which represent the circular cross section of the wooden dowels that were used for joining the tenons to the wooden panel. During the construction of the shrine these joints were embedded inside the wood, and totally covered with gesso; but after centuries of burial in the dry tomb, wood gradually lost its moisture content and shrunk unequally in its three directions due to the anisotropic properties of wood. Therefore, all the wooden panels shrank in both radial and tangential directions more than in the longitudinal direction, whereas the dowels that had been inserted perpendicularly across the panels did not shrink at the same rate as the panels themselves, causing the aforementioned slight protrusion. The south, west, and northern sides of the shrine were all constructed according to a complex structural system in which alternating wooden tenons were distributed almost at equal distances, forming a 'step' structure to join the panels together. This structure was obtained by an overlap of half the length of the vertically positioned tenons adjacent to each other. The tenons that joined the horizontal panels are relatively long, yet they are not as wide as the shorter horizontal tenons that were used to join the south and north panels to the corner posts fig. (4).

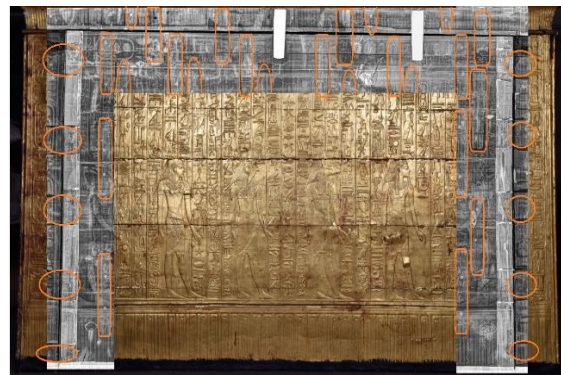


Figure (4) the south side of the innermost shrine, the x-ray radiographs were all merged together and added to the color image of the shrine. Rectangles represent the vertically dowelled wooden tongues and the oval shapes represent the horizontal tongues that were used to join the side panels to the corner.

The idea behind the distribution of the tenons, their different dimensions according to their position in the panels and the variety of materials chosen according to structural design was brilliantly exerted. However, as noted in the hand notes by Carter in February 1924, while comparing the woodwork quality of the shrines he stated that “Both the third and fourth shrines show signs of having been very carelessly put together, many of the joints were not even properly closed” (TAA_i_2_1_107) [12]. This fact was confirmed by the findings in the x-ray images, in which it was clear that some of the mortises had not been carved neatly, such as the example seen in fig. (5) of the mortise that housed one of the metal tongues and an adjacent one had been clumsily carved for a wooden tenon. However, it is worthy to note that in the eastern side of the shrine the application of the joinery technique was very fine, and all the gaps around the wooden tenon had been filled with an ancient gap filler that had a density slightly higher than the wooden panels. Each tenon was fixed in its place with two wooden dowels that ran perpendicularly against both the plank and tenon. In the detailed picture in fig. (6) the ancient gap filler can be seen around the tenon, because the inner surface of the frieze in the east end panel had been removed by the ancient craftsmen due to a design error. In addition to the previous findings, the x-ray images in fig. (6) clearly indicate that a different wood type with a density higher than the of rest of the planks forming the shrine panels was used as an outer frame of each door panel. The saturation of the gray color of the door rails and latch and hinge sides is very close to that of the ebony bolts, and in the overlap area between the door latch and the wooden bolts the gray color is even brighter.

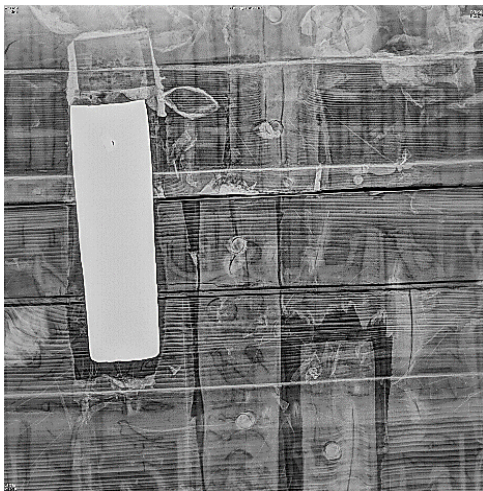


Figure (5) X-ray radiograph of a wooden panel part, showing a metal tongue and two dowelled wooden tongues. The carved mortise of the lowermost wooden tongue is an example of imprecision by the carpenter.

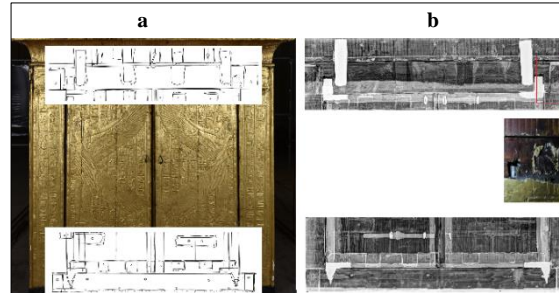


Figure (6) photography, X-ray radiography and AutoCAD of the eastern façade, in which all the metal parts are represents; pivots, U-shaped binding, silver door hoops, ebony bolts, metal and wooden tongues neatly embedded in the mortise and surrounded with a gap filler.

4. Discussion

Carter and Lucas documented their thoughts and theories concerning the woodworking quality whenever possible, but from the different imaging techniques it is seen that the panels were not made by the same craftsman, especially the wood joints. This was also confirmed from the results obtained from the gold analysis. The nondestructive documentation and analysis conducted in this paper are very helpful in explaining a few ancient woodworking techniques. The distribution of the wooden tenons used to join the cedar planks together forming sturdy panels, their dimensions or choice of material depending on their position and use within the shrine is comprehensible. It is also possible to recognize that the carpenter used different types of wood in the door panels, in which he chose a denser type of wood for the latch and hinge sides, and the upper and lower rail. From the x-ray images of the south panel fig. (4), there is a high possibility that here too the edges of the panel, where the horizontal tenons of the panels were fitted, were composed of a dense type of wood. These findings were not obvious in the past, because the shrine had not been x-rayed, and all these details are hidden beneath the gilding layers. Nevertheless, planks excavated back in 1907 from tomb number 55 in the valley of the kings, which are fragments of the shrine of queen Tiye (J.E. 57175) that was a gift from Akhenaten to his mother, confirm some of the aforementioned carpentry techniques. A complete study of the different metals used in the shrine was conducted using Portable X-Ray Florescence to identify their composition and to understand the difference in color of the gilding layer which was used to cover the entire interior and exterior sides of the shrine. By examining and analyzing the gilding layer, the presence of two types of gold leaf was confirmed. Analyses was conducted for the entire gilded surface of the shrine and the results were the same for the two different colors. The yellow gold leaf was composed of pure gold (Au) and contained impurities of copper (Cu) and Iron (Fe), whereas the yellow reddish color was found to be

composed of gold and silver (Ag) and also contained traces of copper and iron, tab. (1). There was a high number of gold production sites in the Eastern Desert of Egypt and Nubia in ancient Egypt, and there were different varieties of the primary gold occurrences. From the New Kingdom (1550-1070 BC) period onwards, gold mining operations concentrated more in the central Eastern Desert, predominantly south of the Qena-Safaga road, and were also spread over the eastern portion of the Red Sea hills, the Wadi Allaqi area and deep into the NE Sudan [13]. Distinctive red and sometimes purple surface coloration frequently found on ancient Egyptian gold work has been examined by different analytical methods. The reddish-brown color that was tested in the objects belonging to Tutankhamun indicated the presence of iron, silver, and copper, and was assumed to be due to iron and copper in the gold that had oxidized [14]. In other research, the results indicate that this discoloration is often associated with tarnish films in which the predominant component is a silver gold sulfide, AgAuS, occurring on a substrate silver gold alloy. Another silver gold sulfide, Ag₃AuS₂, may also be associated with these alloys and especially those of higher silver content [15]. These results have been corroborated by the synthesis of visually similar tarnish on gold silver alloy coupons that have yielded analytical results identical to those obtained from the archaeological material. In most instances, however, red films on Egyptian gold are irregular in expanse, varied in hue, and have no discernible stylistic or iconographic function [16], as seen in the innermost shrine, where red and yellow gold are irregularly dis-

tributed within the panels. The metal nails used for joining the metal tongues to the wooden cornice proved to be made of a copper alloy and contained a high percentage of sulfur (S). A total of nine metal tongues - two in the east side, three in the north side, two in the south side, and two in the west side - had been used in the innermost shrine alternatingly with wooden tenons. The metal tongues that connect the ceiling with the sides are made of a copper alloy containing a percentage of tin (Sn) that does not exceed 2% and a high percentage of chlorides (Cl). Lucas (1927) wrote that the "copper or bronze objects" had not been analyzed, and it was therefore impossible to confirm which of the metals had been used in the shrine [14]. In a document by Plenderleith (without date), the chemical components of one of the metal tongues which secured the second shrine lid proved to be of copper containing some tin and a little gold (TAA.i.3.9.1) [17]. The U-shaped copper binding at the base of the shrine is also made from a copper alloy, which contains a percentage of tin that does not exceed 2%; although, in the chemical analysis by Scott (1927), it was noted that the alloy contained 2.5% tin [18], tab. (1). The metal door hoofs used in the door of the shrine in the eastern façade were composed of a silver and copper alloy covered by layers of sulfur corrosion compounds that appear black. They were described by Scott (1927) as "staples of metal into which the ebony bolts slide", that had been both examined with the microscope and chemically analyzed, leading to the conclusion that the silver originally was "applied in the form of a thin malleable sheet" [14].

Table (1) a comparison between the analysis conducted in the past and recently applied XRF analysis (%), which are more accurate in the percentage of elements.

Metal Part	Lucas/ Scott/ Plenderleith	Rifai & El Hadidi 2010 (%)	Recent XRF (%)
Yellow Gold	Fairly pure and corresponds to fine gold (Lucas, 1927, p.173)	Au 70.98	Sample A
		Cu 1.19	Au 98.68
		Ag 0.75	Cu 0.88
		Fe 0.94	Fe 0.44
Red Gold	Tarnishing of silver and iron-bearing gold (Lucas, 1927)	Au 69.43	Sample B
		Ag 12.30	Au 95.62
		Pt 7.44	Ag 3.36
		S 9.23	Cu 0.32
Copper nail for metal tongues	-----	Cu 0.26	Fe 0.7
		Fe 0.13	Sample C
			Ag 0.88
			Cu 66.16
Door Hoops	Silver coated metal handles (Scott, 1927) p.205)		Fe 1.04
			S 31.16
			Zr 0.52
			As 0.44
Metal Tongues	98.39 % Copper 1.54 % Tin 0.07 % Gold (TAA.i.3.9.1)		Sample D
			Au 0.66
			Ag 33.36
			Cu 5.13
Pivot Hinges	Copper		S 60.85
			Sample E
			Cu 78.69
			Fe 0.55
Copper binding	97.2 % Copper 2.5 % Tin 0.8 % Silver (Scott, 1927, p.205)		Zr 0.
			Cl 18.13
			Sn 1.71 %
			Sample F
		Cu 80.35	
		Fe 0.35	
		S 17.49	
		Sn 1.8	



Exterior of the eastern façade of the innermost shrine of King Tutankhamun indicating the XRF analysis spots.
A. Yellow Gold
B. Red Gold
C. Copper Nail for metal tongues
D. Door Hoops
F. Copper Binding



Interior of the shrine showing the strong contrast between the yellow gold and the red gold.

5. Conclusion

The different documentation methods shed new light in understanding the technology behind the making of the shrines. The results obtained while studying the innermost shrine of Tutankhamun using non-destructive techniques to document and analyze its components was in accordance with chemical analysis conducted in the 1920's. However, the type(s) of wood used in the shrine remain unconfirmed due to inconsistencies among previous studies. Additionally, the non-destructive techniques employed in this article may not provide a comprehensive understanding of the wood type. Furthermore, it is still very difficult to find a clear and definite explanation for the following points. The gilded layer was so finely prepared, yet the gold leaves are not of the same composition which led to the presence of both yellow and red gold distributed in a non-systematic manner both inside and outside the shrine. From the x-ray images, it is very obvious that the tenons and mortises were roughly carved out in some parts; a feature that is not often seen applied in ancient Egyptian carpentry for royals. Could it be possible that in the rush to complete the funerary furniture of the young king, gold leaves were collected from different workshops and carpenters did not have enough time to finely carve the joints that were to remain hidden inside the panels? Or was the rough carving of tenons and mortises likely a result of their function as hidden elements, which did not require precise construction? One hundred years ago, when the samples of the different objects found in the tomb were studied, Alfred Lucas' results were considered a breakthrough in archaeological chemistry. Currently with the advancement of archaeometry it is possible to clarify some technologies issues, however, research limitations, technical investigation protocol and sampling procedures still make it difficult to obtain answers for some of our questions. There is no doubt that a lot of research in the future may unveil more details on the wood industry and gilding technology in ancient Egypt, which depended on simple hand tools for the manufacture of amazing masterpieces. With the development of non-destructive or micro-destructive analytical tools there are high expectations for explaining how the ancient technologies developed in the past.

References

- [1] The Griffith Institute. <http://www.griffith.ox.ac.uk/Gri/Carter/207-C207-02.html> (12/1/2025)
- [2] Carter, H. (1927). *The tomb of Tut-Ankh-Amen, discovered by the Late Earl of Carnarvon and Howard Carter*, Vol. II, Cassell & Company Ltd., London.
- [3] The Griffith Institute. http://www.griffith.ox.ac.uk/Gri/Tut-scans/taa_i_3_23_1.Jpg (12/1/2025)
- [4] The Griffith Institute. http://www.griffith.ox.ac.uk/gri/gif-files/TAA_i_2_11_88&89. Pdf (10/4/2025)
- [5] The Griffith Institute. http://www.griffith.ox.ac.uk/gri/gif-files/TAA_i_2_11_94&95. Pdf (10/4/2025)
- [6] Waly, N. (1996). Identified Wood specimens from Tut Ankh Amon funerary furniture. *Taeckholmia*. 16: 61-73
- [7] Rifai, M. & El Hadidi, N. (2010). Investigation and analysis of three gilded wood samples from the tomb of Tutankhamun. In: Dawson, J., Rozeik, C. & Wright, M. (eds.) *Decorated Surfaces on Ancient Egyptian Objects, Technology, Deterioration and Conservation*, Archetype Pub., London, pp. 16-24
- [8] Hatchfield, P. & Newman, R. (1991). Ancient Egyptian gilding methods. In: Bigelow, D. (ed.) *Gilded Wood: Conservation and History*, Sound View Press, Madison CT, pp. 27-47
- [9] Oddy, W. (1991). Gilding: An outline of the technological history of the plating of gold on to silver or copper in the old world. *Endeavour*. 15 (1): 29-33
- [10] Darque-Ceretti, E., Felder, E. & Aucouturier, M. (2011). Foil and leaf gilding on cultural artifacts: Forming and adhesion. *Matéria* (Rio de Janeiro). 16 (1): 540-559
- [11] Bell, M. (1990). Notes on the exterior construction signs from Tutankhamun's shrines. *The J. of Egyptian Archaeology*. 76: 107-124
- [12] The Griffith Institute. http://www.griffith.ox.ac.uk/discoveringTut/journals-and-diaries/images/large/TAA_i_2_1_107.jpg (2/1/2025)
- [13] Klemm, D., Klemm, R. & Murr, A. (2001). Gold of the Pharaohs – 6000 years of gold mining in Egypt and Nubia. *African Earth Sciences*. 33: 643-659
- [14] Lucas, A. (1927). The chemistry of the tomb, appendix II. In: Carter, H. (ed.) *The Tomb of Tut-Ankh-Amen, Discovered by the Late Earl of Carnarvon and Howard Carter*, Vol. II, Cassell and Company Ltd., London, pp. 172-178
- [15] Frantz, J. & Schorsch, D. (1990). Egyptian Red Gold. *Archeomaterials*. 4 (2): 133-152.
- [16] Schorsch, D. (2001). Precious-metal polychromy in Egypt in the time of Tutankhamen. *The J. of Egyptian Archaeology*. 87: 55-71.
- [17] The Griffith Institute. http://www.griffith.ox.ac.uk/gri/tut-scans/taa_i_3_9_1.jpg (23/10/2025).
- [18] Scott, A. (1927). Notes on the objects from the tomb of King Tut-Ankh-Amen, Appendix IV. In: Carter, H. (ed.) *The Tomb of Tut-Ankh-Amen, Discovered by the Late Earl of Carnarvon and Howard Carter*, Vol. II, Cassell and Company Ltd., London, pp. 197-213