Advanced Research in Conservation Science

Journal homepage: https://arcs.journals.ekb.eg

DOI: 10.21608/arcs.2022.136413.1026

Multidisciplinary approach for documentation of an Anthropoid Wooden Coffin from the Late Period in Egypt

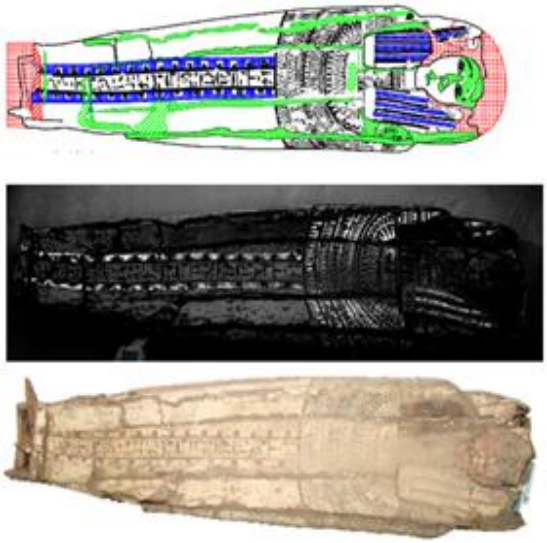
Abdelmoniem M. Abdelmoniem[a*], Naglaa Mahmoud[a], Saleh Mohamed[a], Mostafa Ahmed Abdel-fatah[b], Mokhtar Mohammad[c], Nour M. Badr[d]

a. Conservation Department, Faculty of Archaeology, Fayoum University, 63514 Fayoum, Egypt.
b. Ministry of Tourism and Antiquities, Egypt
c. Egyptology Department, Faculty of Archaeology, Fayoum University, 63514 Fayoum, Egypt.
d. Conservation Centre, The Grand Egyptian Museum, Ministry of Tourism and Antiquities, Egypt

HIGHLIGHTS

- Use several techniques for the documentation of the wooden coffin.
- Diagnose the Deterioration factors of the wooden coffin.
- Using AutoCAD and Illustrator programs for documentation.
- Agisoft PhotoScan program was used to generate a metric 3D model.
- Interpretation and documentation of hieroglyphic texts

GRAPHICAL ABSTRACT



ARTICLE INFO

Article History:
Received: 29 April 2022.
Revised: 1 June 2022.
Accepted: 26 June 2022.
Available online: 29 December 2022.

Keywords:
Wooden coffin, Photogrammetric documentation, Technical photography, 2D illustrations, 3D models.

ABSTRACT

This paper aims to document the current state of an anthropoid wooden coffin using different methods and to provide necessary information for suitable future conservation works. Text transliteration, photographic documentation, technical photography, 2D illustrations, and 3D modules were utilized to document the coffin. The results showed the presence of an insect infestation in the head of the coffin. Text transliteration showed that the studied coffin dates back to the late period in ancient Egypt.

*** Corresponding author: Abdelmoniem (ama63@fayoum.edu.eg**

2D illustrations showed the places of the previous conservation and missing parts of the coffin. Moreover, 3D modules showed that the lid of the coffin had an inward curvature. Technical photography highlighted the places of the previous conservation and the area of the Egyptian blue color.

1. Introduction

Digital analysis of artifact morphology has become an increasingly affordable and accessible method of archaeological investigation [1. The recording of the cultural objects is the first step for the accomplishment of cultural documentation and further preservation, conservation, and publication [2]. Polychrome wooden coffins were one of the most important archeological materials as they contained colors, scenes, texts, and ancient writings that revealed important historical information, facts, and secrets [3]. However, wooden artifacts underwent complex alteration and degradation during aging [4].

The coffin was discovered in Saqqara and was transferred to the Dahshur archaeological site after the January Revolution in 2011. The coffin under registration number T. C 339. The size of the coffin is relatively small, and the color of the face is bright red. It may belong to a woman. It consists of body and lid which formed by many wooden pieces. The coffin lid was coated from the outside with two preparation layers. the first preparation layer was composed of mud mixture applied on the entire surface of the lid to act as a leveling surface, the second one was a fine layer composed of calcium carbonate, as a preparation for the coloring process [5] and decorated with a painted layer (red, blue, yellow, white, and black). The interior of the coffin was composed of wood only without any pigments. The painted layers of this coffin suffered from many deterioration aspects, including powdering, flaking, cracking, and missing parts. Furthermore, it was covered with a thick layer of dust resulting from previous inappropriate conservation [6] and bad storage inside the storerooms of Dahshur archaeological site, Egypt. The present study aims to use several techniques for the documentation of the coffin.

2. Materials and methods

Visual assessment

The critical eye of the conservator could help diagnose the deterioration factor and choose the best technique for the conservation process of the coffin [7, 8].

Photographic documentation

Photographic documentation was used to document the current state of the coffin and the aspects of damage. The images were also used in 2D and 3D documentation using a smartphone camera and a Sony A6000 digital camera.

Transliteration of hieroglyphic texts

JSesh program was used to document hieroglyphic texts on the lid of the coffin *JSesh* is a word processor for documenting hieroglyphic texts. Its texts can be copied and pasted into other software (e.g., MS/Word or Open office). It is also possible to create pictures in various graphical formats (JPEG, PNG, PDF, SVG, EMF, MACPICT, etc.) [9].

Technical photography (TP)

Technical images were obtained using a modified digital camera for documentation and initial color check. Technical Photography (TP) helped identify the previous conservation [10] and non-destructive diagnostics of paintings [11]. This method was commonly used to identify the pigments [12-14]. It depends on the camera, lens, and different filters [15-17]. It was applied to colored wooden coffins in previous research [18-20]. Various electromagnetic spectrum bands provide a quick but detailed analysis of the works [21].

MSI images acquired in 4 spectral bands [22]: ultraviolet [23] (360-400 nm) [24], UV show us previous conservation to select non treated area for analysis [25] visible (400-780 nm), and infrared [26] (780-1700 nm). infrared used for detecting and visualize under drawings in paintings [27] IRF (Infrared

Fluorescence) [28] visible-induced infrared luminescence (VIL) and infrared (IR)) presented in this study.

Technical images were taken using a Sony A6000 digital camera modified to "full spectrum" with a 90C IR Filter and a LED lamp to view the fluorescence (luminescence).

The camera was equipped with a Sony A6000 digital camera. Visible (Vis) images were acquired by using two sources of two fluorescent lamps. Two UV 365nm LED lambs were used for ultraviolet (UV). In the case of infrared Fluorescence (IRF) image two LED lamps illuminated the coffin and a Schott RG840 cut-on filter was placed in front of the lens, to block all stray radiations from visible spectrum and investigate only the emission of IR radiation in the 850–1000nm region. a Schott RG840 cut-on filter was placed in front of the lens to prevent the visible component and investigate the range between 850 and 1000nm. The X-rite Color Checker Passport was used as a reference alongside the coffin [29].

2D documentation

Adobe Illustrator and Auto CAD were used to highlight the decoration of the lid of the coffin (Fig.2), which helped translate the decoration to document further information about the coffin [30, 31] and document the signs of damage on the wooden coffin.

Agisoft PhotoScan program was used for photogrammetric documentation to make a 3D modules of the images [32, 33]. It is an inexpensive technique [34] used to create a 3D module, but there must be an overlap among the photos [35]. It helps anyone see cultural heritage sites and steps to perform the excavations and exhibit them in specialized museums [36, 37].

To generate a metric 3D module, only a series of high quality photographs documenting the scene and at least three ground control points (GCPs) with known xY, yY and zY coordinates are required [38].

To create the modules through a four-step system it is necessary that:

1. The software aligns the photographs through the matching of their common points between, which requires a significant overlap between photographs, generally 70–80%. An output of the camera alignment is a sparse point cloud along with a representation of the camera's position for each photograph.
2. Based on the camera positions identified in step 1, the software can produce a dense point cloud.
3. Photoscan can create a 3D polygonal mesh based on the dense point cloud. This represents the surface or structure of the photographed subject.
4. A texture can be provided for the mesh utilizing of the original images taken of the feature, providing a 3D photorealistic representation [39-41].

USB light digital microscope

The structure of the painted layer fragments was studied using a Veho digital USB microscope with a 1.3 MP visible light digital camera (variable magnification of 20–200×.

Scanning Electron Microscope attached with Energy Dispersive X-Ray (SEM-EDX)

Identifying the elemental composition of the Egyptian blue were performed using a Quanta 250 FEG with SEM-EDX (Energy Dispersive X-ray Analyses). The accelerating voltage was 30 K.V.

3. Results and discussion

The coffin suffered from many aspects of damage, such as separation on the mud ground layer and gesso layer, loss of the painted layer, many micro and macro cracks, as well as loss of the head area on the lid and the foot area of the coffin (Fig. 1. a, b and c) (Fig. 2.a-i). Moreover, a thick layer of dust covered the coffin. There was an insect infestation on the coffin. There were traces of previous conservation materials on the lid and left and right sides of the coffin. There was a curvature in the lid of the coffin It may be curvature in the lid during discovery or from poor storage

The previous conservation was for the purpose of strengthening the coffin, as the coffin consisted of a group of wooden boards(Fig.3a), and a layer of mud was made on it to level the surface and in preparation for the ground layer and colored layer.

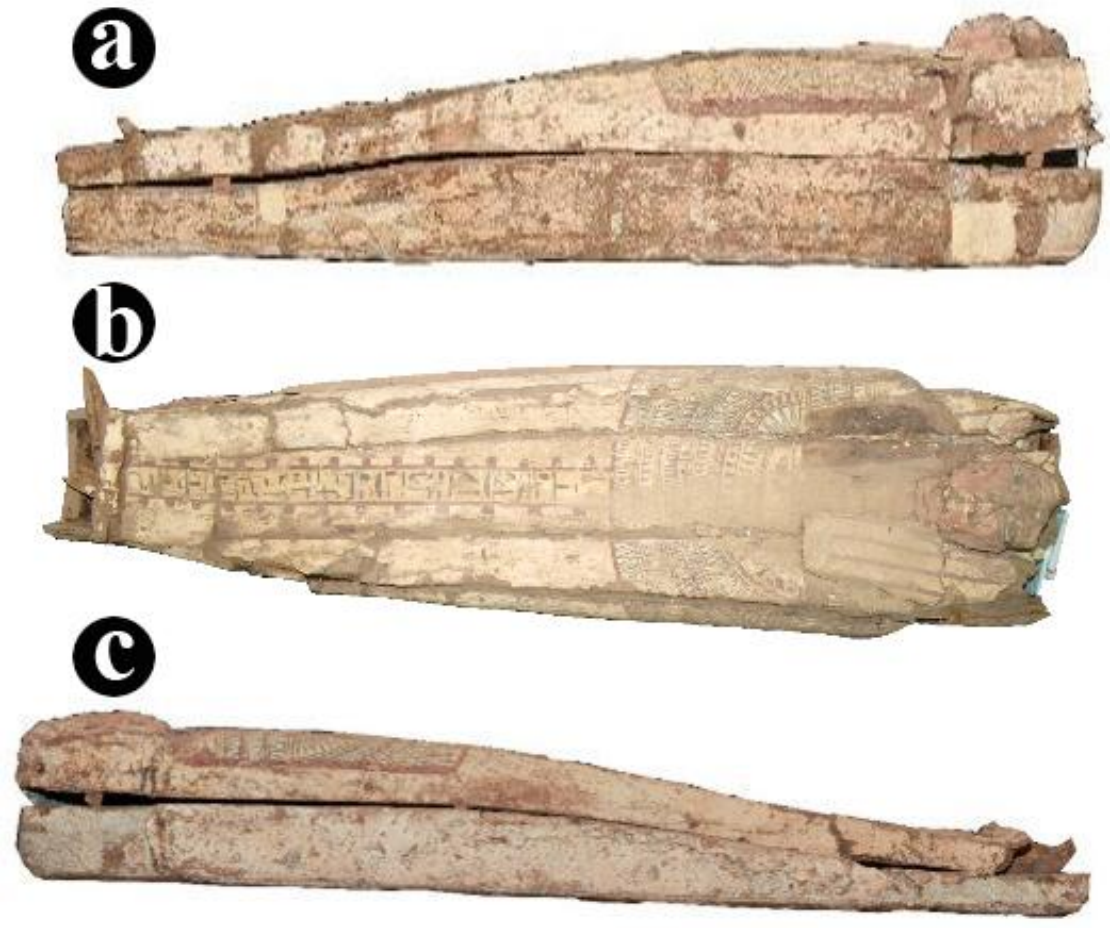


Fig. 1. General View of the coffin; a) right side; b) exterior of the coffin; c) left side.

The previous conservation was using primal with cotton to fill the voids (Fig. 3b), in pervious conservation it must be use a good holder to support the lid from inside and no good holders were used to lift the coffin lid after treating the curvature so it was very important to document the current state of the coffin to help us on future conservation works.

There are many tunnels for insects in the head area of the coffin, which requires that there be a complete sterilization before the conservation process to find out whether the infestation is live or inactive. Insects feed on the organic materials in the muddy structure, which increases its deterioration

Translation and interpretation of the hieroglyphic text

- An offering made by the king to Osiris, the master of Mendes (Tel-Rub'), the great god
- The Lord of heaven, king of the gods, ruler of eternity, may he give offerings and food (Fig. 4)

The interpretation of the text is a line on the lid along the length of the sarcophagus. It was written by drawing. Some hashs and cracks extended over it. The text includes the formula of the offering or the formula of *al-hotb de nsu* [42], which was one of the most famous formulas in ancient Egypt.

Fig. 2. Deterioration aspects on the coffin: A & b) Flaking and missing parts; c) Cracks; d) Previous gap filing; e) Old insect attack; f) Missing parts; g) Some parts wrongly reassembled and missing parts; h) Thick layer of dust and cracks; i) Missing parts

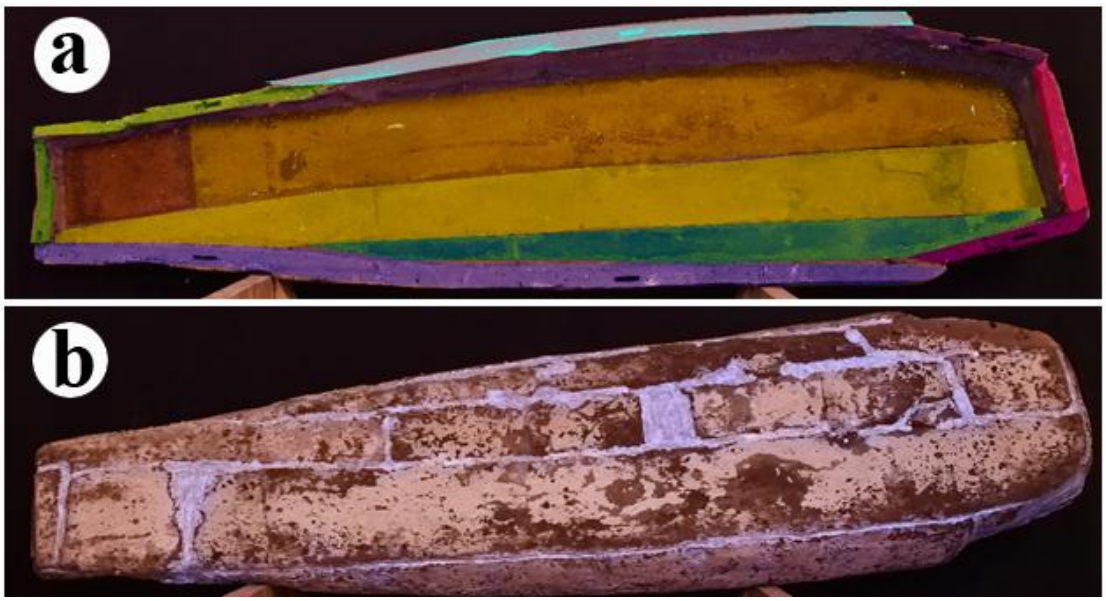


Fig. 3. The base of the coffin; a) the wooden panels of the base of the coffin from inside ; b) the base of the coffin from outside showed the previous restoration

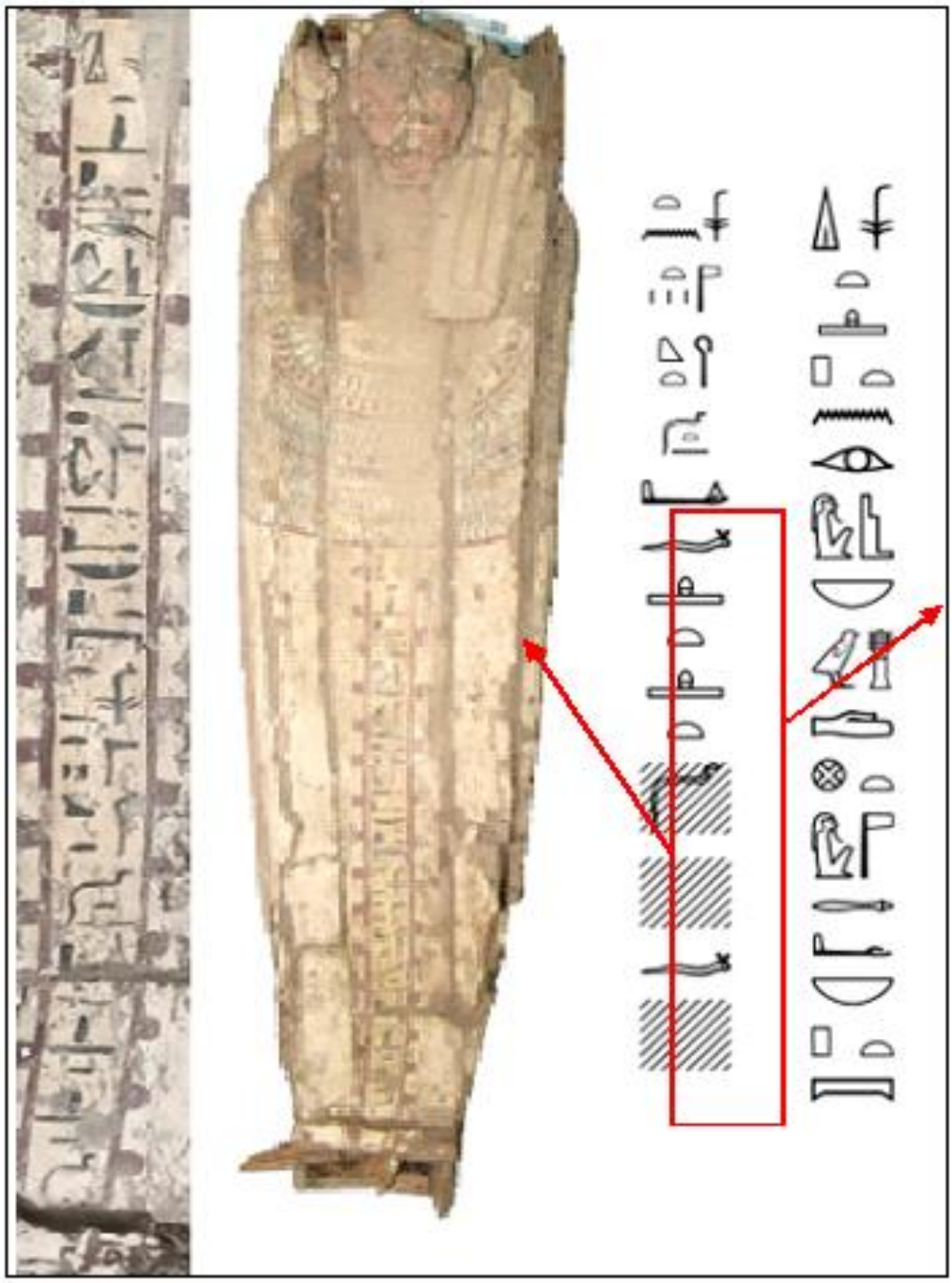


Fig. 4. Transliteration of the Hieroglyphic texts of the central decorative panels on the lid of the coffin

Here, the offering formula is for the god *Osiris*, the god of the dead, that was one of the most well-known gods with this formula in addition to the god *Anubis*, *Wub*, *Awut*, *Ptah* and others. The titles of this god were numerous in this formula, the most important of which was the master of Mendes (current Tel-Rub' area in Delta). This may prove that the owner of this coffin was from that region. Usually, gods took the titles of the Master of Abu Sir and the Master of Abydos as the main areas of their worship. In later periods, however, his worship spread in many areas, and the formula of offerings did not include the different types of food, as

usual, but included offerings and food, in general.

2D documentation

The condition of the coffin was recorded using 2D program. The schematic diagram documented the deterioration aspects of the coffin and highlighted the fading of Egyptian blue on the lappet of the wig and both sides of the central decorative panels, and the red color of the module for imagining of the head and foot area of the coffin and help conservator on future conservation process (Fig. 5. a, b and c).

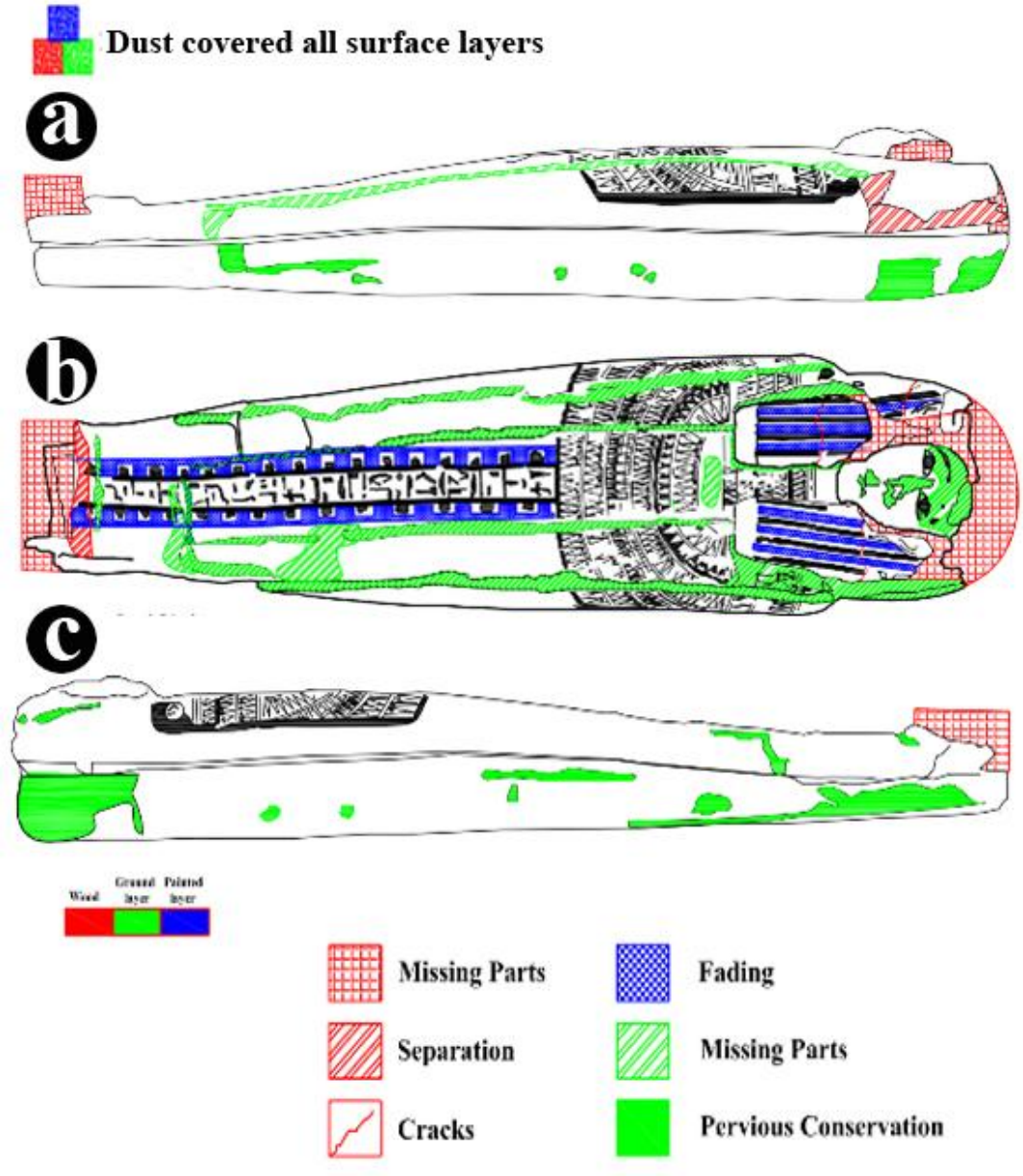


Fig. 5. Schematic diagram of the coffin showing the deterioration aspects in 2D Program: a) right side; b) exterior of the coffin; c) left side

Technical Photography

Technical Photography showed the blue painted layer that appeared white bright in the VIL image (Fig. 6), suggesting the use of Egyptian blue [43, 44] but did not appear in visible light. There was an Egyptian blue pigment on the upper and abdomen of the lid and fading Egyptian blue on both sides of the central decorative panels. The EDX of the Egyptian blue showed calcium (Ca), Copper (Cu), silicon (Si), and oxygen (O), $CaCuSi_4O_{10}$. that confirm the use of Egyptian blue.

From technical Photography (TP) it can also show the arrangement of the color palette that the ancient Egyptian used on the coffin. IRF showed that the ancient Egyptian painted blue pigment first and used the red pigment to fill selected areas (Fig.7 a and b). Then, they used the black pigment to determine the outline of paintings on the pectoral area. The ancient Egyptian highlighted the decoration on both sides of the central decorative panels by red pigment and painted the Egyptian blue followed by the red pigment. (OM) image (Fig. 7c) showed that the yellow painted layer was coated with blue painted layer and used the black pigment to determine the outline of paintings (Fig. 7d and e)

Fig. 6. Technical images of the lid of the coffin made by Infrared Fluorescence (IRF)

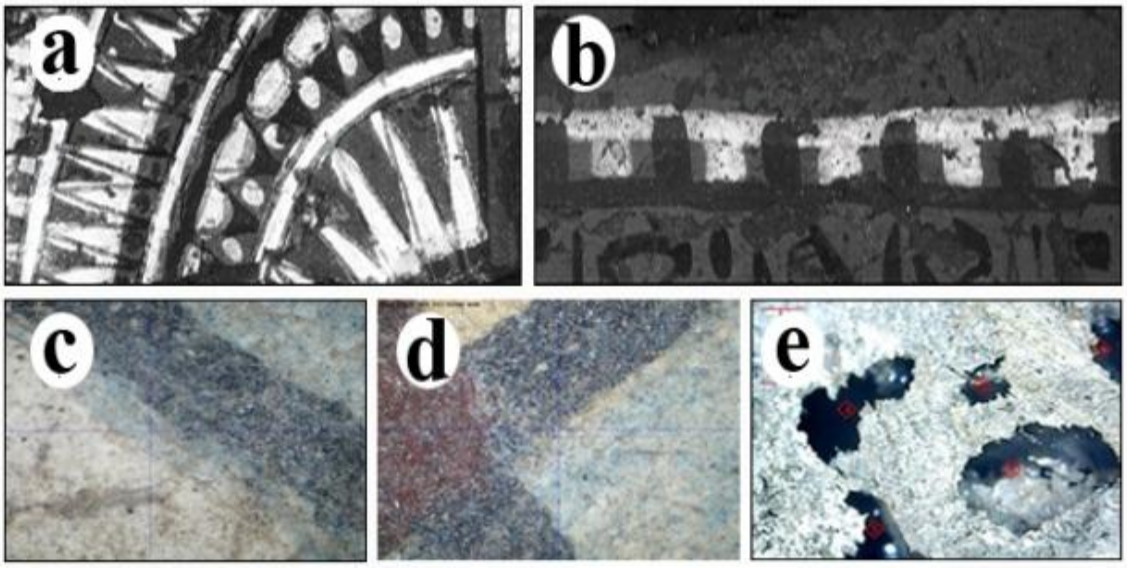


Fig. 7. The color palette of the coffin; a&b) Infrared Fluorescence images shows the color palette Optical photomicrographs showing the course morphology of the painted layers surface used in the coffin: a and b blue ,black, blue layer; c-e insect tunel

Photogrammetric Documentation

The morphological characteristics of the surface of the coffin would be preserved by record [45].

The 3D documentation of the coffin (Fig. 8 a, b) showed the extent of the descent in the lid of the coffin that did not appear well on the photographic documentation (Fig. 8 b, c). The 3D modules helped observe all sides of the coffin on the computer to make good documentation of the condition of the coffin (Fig. 8 e, f) and save the 3D modules on the archive of the Dahshour archaeological area. This could help the conservator to follow up the changes on the surface of the coffin. The 3D module can be uploaded on the Internet to make specialists and common people see the cultural heritage of the ancient Egyptians in museums and storerooms [46] when objects are in accessible or storerooms that are not allowed to the public and require a special statement from authorities.

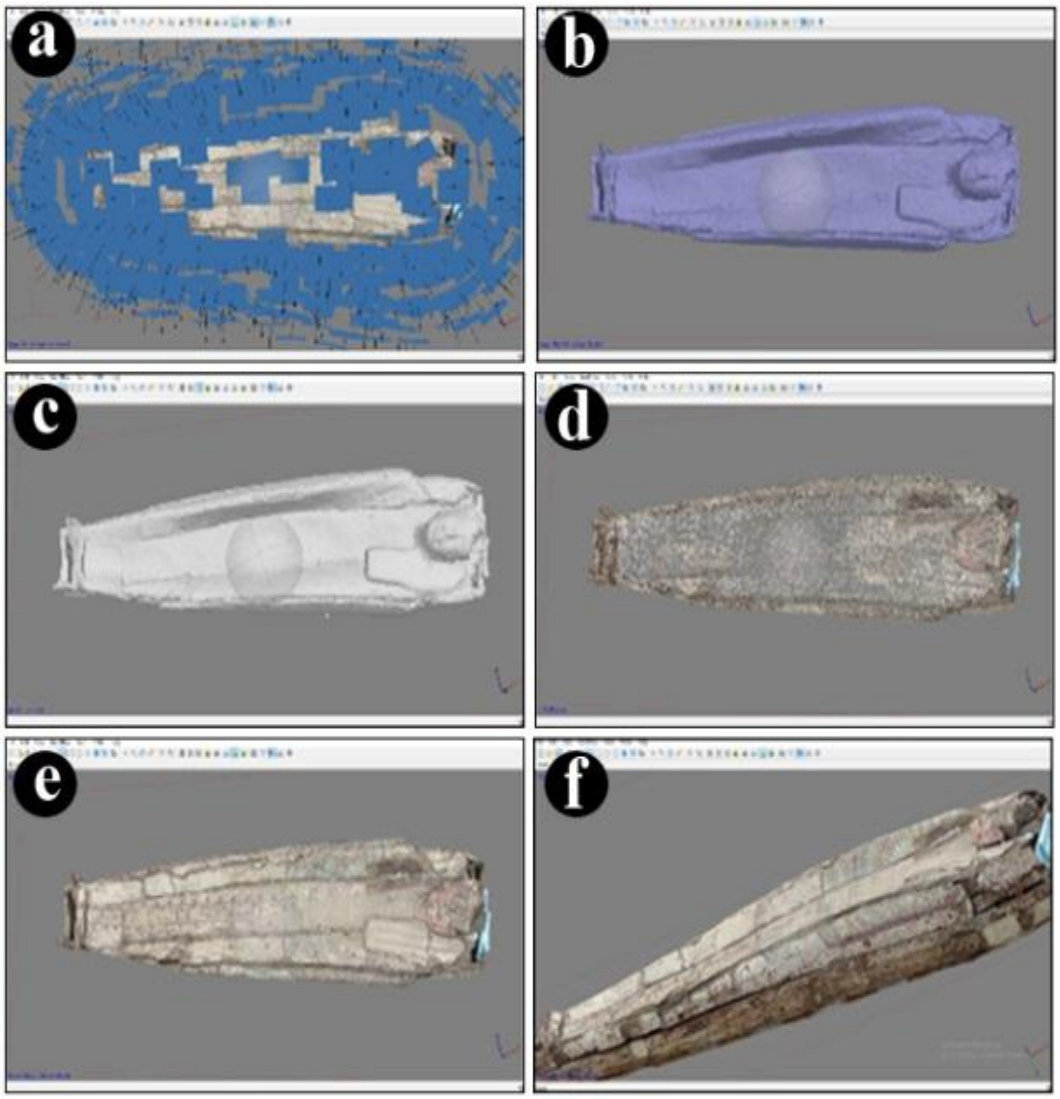


Fig. 8. Stages of producing a 3D modules ;a) camera positions and image overlap; b) solid phase; c) building dense point cloud; d) point cloud;e) generating texture; f) 3D modules

4. Conclusion

This paper presented several methods of digital epigraphy of an anthropoid wooden coffin from the late period stored at Dahshour storeroom as an inexpensive way to document the coffin, fast and accurate 2D and 3D surface recording using computer software. The coffin suffered from several deterioration phenomena, including bad storage and previous conservation. Photographic documentation showed the insect infestation of the coffin and the loss of the painted layer on the lid of the coffin. Moreover, 2D documentation showed the decoration of the coffin, whereas 3D showed the deterioration of the wooden coffin lid. TP illustrated the Egyptian blue pigment on the lid and the fading Egyptian blue on both sides of the central decorative panels.

The use of multiple programs for documenting coffins gives a better opportunity to understand the secrets and methods of decorating and manufacturing coffins. It is also useful in keeping these documents in the archive in conservation laboratories and very important in future conservation operations.

References

1. C. E. Heckel, "Digital morphometric analysis of Upper Palaeolithic beads: Assessing artifact variability with user-friendly freeware. Journal of Archaeological Science: Reports, Vol, 10, 2016, pp. 893-902.
2. Y. Alshawabkeh, N. Haala, D. Fritsch, A new true ortho-photo methodology for complex archaeological application. Archaeometry, Vol. 52, No. 3, 2010, pp. 517-530.
3. M. Abdelmoniem, N. Mahmoud, W. S. Mohamed, A. Y. Ewais, A. Abdrabou, Archaeometric Study of A Polychrome Wooden Coffin From 26 Th Dynasty Egypt. *Mediterranean Archaeology & Archaeometry*, Vol. 20, No. 1, 2020, pp. 7-17.
4. M. Abdelmoniem, N. Mahmoud, S. Sayed, W. S. Mohamed, Characterization of the best consolidation material for black resin for the late period coffin. Scientific Culture, Vol. 6, No. 1, 2020, pp. 1-7.
5. H. Afifi, S. Abd El-Kader, M. Hamed, S. Mohamedy, M. Dawod, A dating approach of a refundable wooden Egyptian coffin lid. Scientific Culture, Vol. 5, No. 1, 2019, pp. 15-22.
6. N. El Hadidi, H. Abdel-Monem, M. Mohamed, G. Hashem, Retreatment and Conservation of a Wooden Panel Previously Treated with Bees Wax. Advanced Research in Conservation Science, Vol. 1, No. 2, 2020, pp. 48-65.
7. A. Abdrabou, M. Abdallah, M. Abd El Kader, Analytical study and conservation processes of a painted wooden Graeco-Roman coffin. International Journal of Conservation Science, Vol. 6, No. 4 ، 2015, p. 574.
8. M. Abdallah, A. Abdrabou , H. M. Kamal, Analytical Study And Conservation Processes Of Tutankhamen Decorated Stick: A Case Study , Scientific Culture , Vol. 4, No. 1 , 2018, p. 94.
9. Rosmorduc, Serge.. JSesh Documentation. [online] Available at: http://jseshdoc.qenherkhopeshef.org [Accessed 23 Jun. 2021].
10. A. Abdrabou, M. Abdallah, H. M. Kamal, Scientific investigation by technical photography, OM, ESEM, XRF, XRD and FTIR of an ancient Egyptian polychrome wooden coffin. Conservar Património, Vol. 26, 2017, p. 53.
11. R. Fontana, M. C. Gambino, M. Greco, L. Marras, M. Materazzi, E. Pampaloni, P. Poggi, New high-resolution IR-color reflectography scanner for painting diagnosis. In Optical Metrology for Arts and Multimedia, International Society for Optics and Photonics, Vol. 5146 , 2003, P. 108.
12. https://chsopensource.org/multispectral-imaging-system/ 23/2/2018.
13. Y. Zhao, R. S. Berns, L. A. Taplin, J. Coddington, An investigation of multispectral imaging for the mapping of pigments in paintings. In Computer image analysis in the study of art.

International Society for Optics and Photonics, Vol. 6810, 2008, 681007.
14. J. Dyer, E. O'Connell, A. Simpson, Polychromy in Roman Egypt: a study of a limestone sculpture of the Egyptian god Horus. Brit Mus Tech Res Bull, Vol. 8, 2014, PP. 93-103.
15. C. S. Chane, M. Thoury, A. Tournié, J. P. Echard, Implementation of a neural network for multispectral luminescence imaging of lake pigment paints. Applied spectroscopy, Vol. 69, No. 4, 2015, p. 431.
16. https://chsopensource.org/multispectral-imaging-system/ 28/11/2019.
17. F. Korenberg, L. Pereira-Pardo, P. J. McElhinney, J. Dyer, Developing a systematic approach to determine the sequence of impressions of Japanese woodblock prints: the case of Hokusai's 'Red Fuji'. Heritage Science, Vol. 7, No. 1, 2019, pp. 1-11.
18. D. A. Scott, Egyptian Sarcophagi and Mummies in the San Diego Museum of Man: Some Technical Studies. Studies in Conservation, 2017, pp. 215-235.
19. http://chsopensource.org/chsos-technical-photography-kit/ 23/2/2018.
20. H. Liang, Advances in multispectral and hyperspectral imaging for archaeology and art conservation. Applied Physics A, Vol. 106, No. 2, 2012, p. 316.
21. P. Buscaglia, V. Reale, E. Biondi, A. Bovero, T. Quirino. From the lab to the field: 3D technology supporting study and conservation processes on Ancient Egyptian artefacts, Proceedings of the 21st World Multi-Conference on Systemics, Cybernetics and Informatics, WMSCI, 2017, pp. 380-385.
22. A. Cosentino, Panoramic infrared reflectography. Technical recommendations. International Journal of Conservation Science, Vol. 5, No. 1, 2014, p51.
23. M. Thoury, M. Elias, J. M. Frigerio, C. Barthou, Nondestructive varnish identification by ultraviolet fluorescence spectroscopy. Applied spectroscopy, Vol. 61, No. 12, 2007, p.1275.
24. A. Cosentino, Panoramic, Macro and Micro Multispectral Imaging: An Affordable System for Mapping Pigments on Artworks. Journal of Conservation and Museum Studies, Vol .13, No. 1, 2015, pp. 1–17.
25. M. Albéric, K. Müller, L. Pichon, Q. Lemasson, B. Moignard, C. Pacheco, I. Reiche, Non-invasive quantitative micro-PIXE–RBS/EBS/EBS imaging reveals the lost polychromy and gilding of the Neo-Assyrian ivories from the Louvre collection. Talanta, Vol. 137, 2015, pp. 100-108.
26. A. Cosentino, Effects of different binders on technical photography and infrared reflectography of 54 historical pigments. International Journal of Conservation Science, Vol. 6, No. 3, 2005, pp.287-298
27. M. Gargano, N. Ludwig, G. Poldi, A new methodology for comparing IR reflectographic systems. Infrared Physics & Technology, Vol. 49, No. 3, 2007, p. 249.
28. A. Cosentino, S. Stout, Photoshop and Multispectral Imaging for Art Documentation" e-Preservation Science, Vol. 11, 2014, pp. 91-98.
29. A. Abdrabou, M. Abdalla, I. A. Shaheen, H. M. Kamal, Investigation of An Ancient Egyptian Polychrome Wooden Statuette by Imaging and Spectroscopy. International Journal of Conservation Science, Vol. 9, No.1, 2018, pp. 39-54.
30. A. M. Abdelmoniem, Documentation Methods of Polychrome Coffin Dating Back Late Period at Saqqara- Egypt paper presented to online CAA Australasia (Computer Applications and Quantitative Methods in Archaeology) conference on the 11th – 12th September 2020.
31. K. Vértes, *Digital epigraphy*. Oriental Institute, University of Chicago, 2014, p. 58.
32. A. Tarek, I. A. M. Ali, M. Abdelrahman, Visualization, Documentation and Non-Destructive Investigation of an Ancient Egyptian Corn Mummy in a Falcon-shaped Wooden Coffin. Advanced Research in Conservation Science, Vol. 2, No. 1, 2021, pp. 10-20.
33. R. Sacks, C. M. Eastman, G .Lee, Parametric 3D modeling in building

construction with examples from precast concrete. Automation in construction, vol.13, No. 3, 2004, pp.291-312.
34. S. G. Barsanti, F. Remondino, D. Visintini, Photogrammetry and Laser Scanning for archaeological site 3D modeling–Some critical issues' In Proc. of the 2nd Workshop on the New Technologies for Aquileia', V. Roberto, L. Fozzati , 2012, p. 2.
35. M. Chodoronek,'The Use and Application of Photogrammetry for the In-field Documentation of Archaeological Features: Three Case Studies from the Great Plains and Southeastern Alaska' University of Nebraska – Lincoln, 2015, p2.
36. O. Zaitceva, M. Vavulin, A. Pushkarev, E. Vodyasov, 'Photogrammetry: From Field Recording to Museum Presentation (Timiryazevo Burial Site, Western Siberia)' Mediterranean Archaeology & Archaeometry, Vol.16, No. 5, 2016, p. 98.
37. M. Pollefeys, R. Koch, M. Vergauwen, L. Van Gool, Automated reconstruction of 3D scenes from sequences of images. *ISPRS* Journal of Photogrammetry and Remote Sensing, Vol. 55, No.4, 2000, pp. 251-267.
38. J. De Reu, W. De Clercq, J. Sergant , J. Deconynck, P. Laloo,. Orthophoto mapping and digital surface modeling for archaeological excavations an image-based 3D modeling approach. In 2013 Digital Heritage International Congress (Digital Heritage) Vol. 1, 2013, pp. 205-208.
39. H. Thomas, M. A. Kennedy, A new methodology for accurate digital planning of archaeological sites without the aid of surveying equipment. Journal of Archaeological Science: Reports, Vol. 10, 2016, pp. 887-892.
40. J. N. Cerasoni, Vectorial application for the illustration of archaeological lithic artefacts using the "Stone Tools Illustrations with Vector Art"(STIVA) Method. PloS one,Vol. 16, No. 5, 2021, p. 1-4.
41. H. England, Photogrammetric applications for cultural heritage. Guidance for Good Practice, 2017, p. 128.
42. Gardiner,A., Egyptian Grammar,being an Introdcution of the study of Hieroglyphs,third edition Oxford, 2001, p. 170.
43. D. Miriello, R. De Luca, A. Bloise, G. Niceforo, J. Daniel, Pigments Mapping on Two Mural Paintings of the "House of Garden" In Pompeii (Campania, Italy). Mediterranean Archaeology and Archaeometry, Vol. 21, No. 1, 2021, pp. 257-271.
44. E. H. Zidan, S. Mosca, S. Bellei, T. Frizzi, M. Gironda, I. El-Rifai, D. Comelli, In situ imaging, elemental and molecular spectroscopy for the analysis of the construction and painting of a Late Period coffin at the Egyptian Museum of Cairo. Measurement, Vol. 118, 2018, pp. 379-386.
45. G. Plets, W. Gheyle, G. Verhoeven, J. De Reu, J. Bourgeois, J. Verhegge, B. Stichelbaut,. Three-dimensional recording of archaeological remains in the Altai Mountains. Antiquity, Vol. 86, No. 333, 2012, pp. 884-897.
46. O. V. Zaitceva, A. A. Pushkarev, E. V. Vodyasov, M. V. Vavulin, Photogrammetry: from field recording to museum presentation (timiryazevo burial site, western Siberia), Mediterranean Archaeology and Archaeometry, Vol. 16, No 5, 2016, pp. 97-103.