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Conservation of a Wooden Coffin Covered with a Black Resin Layer and Coloured Materials from the 26th Dynasty, Egypt

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HIGHLIGHTS

- 2D Documentation was used for the decorated coffin
- Photogrammetric documentation was made before and after the restoration to document the coffin for future generations.
- Xylene and distilled water (1:1) were used for cleaning the black resin layer.
- Nano paraloid B72 in xylene 1.5% was used for consolidating the black resin layer.

GRAPHICAL ABSTRACT

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ABSTRACT

This paper aims to document the conservation processes of a polychrome wooden coffin from Saqqara dating back to the late period. The exterior part of the coffin is decorated with a painted layer, while the interior part is covered with a layer of the black resin decorated with a depiction of Nut, the goddess of the sky. The coffin was in a bad state of preservation. It was covered with a thick layer of dust, loose fragments of the painted and gesso layers, moreover, some parts of these layers were lost. Several areas were missing from the foot area of the coffin lid. 2D illustrations and 3D modules were made to document the coffin.

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The conservation processes of the wooden coffin included mechanical and chemical cleaning, reattachment of the separated parts of the ground layer and painted layers, filling the edge of the painted layer, and consolidating the black resin layer. The materials used in these processes exhibited stability and high retrievability, as confirmed by multiple researchers. The conservation process included mechanical cleaning using soft brushes, chemical cleaning using ethyl alcohol and water for the painted layer and xylene and water for the black resin layer, stabilization of the separated gesso layer was performed using primal AC33, filling cracks of the gesso layers using glass microballoon with Paraloid B72, consolidating the painted layer was achieved using Klucel E and the black resin layer with Nano Paraloid B72.

1. Introduction

The coffin was discovered in Saqqara dating back to the late period. Saqqara is located to the west of the Nile, 28 km to the south of Cairo. It includes the ruins and monuments from different ages [1]. It was one of the principal necropolises of Memphis; an ancient capital of Egypt [2].

The coffins vary according to age, wealth, and social class. They initially took the form of a simple rectangular shape. Over time, the body of the coffins evolved into a human form. That is, it took the form of a human mummy, and the coffin panels were assembled either by using tenons or a simple interlocking technique. The lid had several tenons in its lower frame that fit into the mortises in the rim of the coffin itself. These coffins often appeared in the New Kingdom. They were gilded or covered with a painted layer [3].

Most of the 18th dynasty's coffins were found in Thebes. The coffins had either feather decorations or rectangular shapes that resembled the coffins from the end of the Middle Kingdom with a straight or flat lid. The decoration of the lid featured geometrical patterns and comprised the forms of Isis, Neptis, Anubis, and other gods. These coffins were poorly made and painted. They continued to be used until the reign of Thutmose III. Then, a new type of wooden coffin that was constructed from sycamore wood and assembled using tenons [4-7] was introduced.

Wood was used mainly in exterior construction and building applications. The present study was conducted to document and evaluate the deterioration of an archaeological wooden coffin that underwent complex degradation and alteration and to implement different conservation measures.

2. Materials and methods

2.1. Visual assessment

The conservator's expertise is essential for diagnosing deterioration issues and selecting the most effective techniques for the conservation of the coffin [8].

2.2. Documentation of the coffin

The coffin was documented using Adobe Illustrator CC 2014 software to illustrate the decoration of the painted layer on the black resin layer [9].

2.3. *Photogrammetric documentation*

The Photo-Scan program was used for photogrammetric documentation. It is an inexpensive technique [10] that is used to create three-dimensional model from images [11,12]. To obtain accurate measurements of the model there must be an overlap among the photos [13,14].

This method also facilitates the visualization of cultural heritage sites and the documentation of excavation processes for display in specialized museums [15].

2.4. Measuring moisture content

A device (model PCE-PMI 1) was used to accurately measure the moisture content in wood artifacts and other materials. This non-destructive device is used in the restoration and maintenance of artifacts and can penetrate 20-40 mm deep. It is positioned on the surface of the artifact and provides results that are interpreted alongside existing data. The device should be held at a 90-degree angle to the surface to measure moisture content [16].

2.5. Measuring temperature

A Hygrotemp device (model Wohler IR Hygrotemp 24) made in the USA, working conditions (measurement of non-contact surface temperature, air temperature and relative humidity as well as dew point and wet bulb calculation. This device is used in measuring air temperature, surface temperature and relative humidity surrounding the artifacts. The temperature is measured by infrared IR [17].

3. Results and discussion

3.1. Visual assessment

The coffin was in poor condition and had previously been restored using beeswax and poly (vinyl acetate). The results of the material analysis from the previous restoration were published in another paper by the author [8]. It was covered with a thick layer of dust (Fig. 1 A-D). Wooden artifacts are susceptible to complex alterations and degradation, and inadequate storage significantly contributes to their deterioration. The warehouse does not have devices to regulate the internal environment, including necessary temperature and humidity controls for preserving valuable antiquities. Furthermore, the constant opening of windows heightens the risk of insect infestations from outside. Several aspects of deterioration were observed on the coffin, including separations, loss of the ground and paint layers (Fig. 1. E-H), a black resin layer covered with a white powder (Fig. 1. I-k), and missing parts from the foot area. The painted layer on the face area appeared fragmented resembling a puzzle (Fig 1. L) due to the poor condition of the coffin resulting from inadequate storage [19].

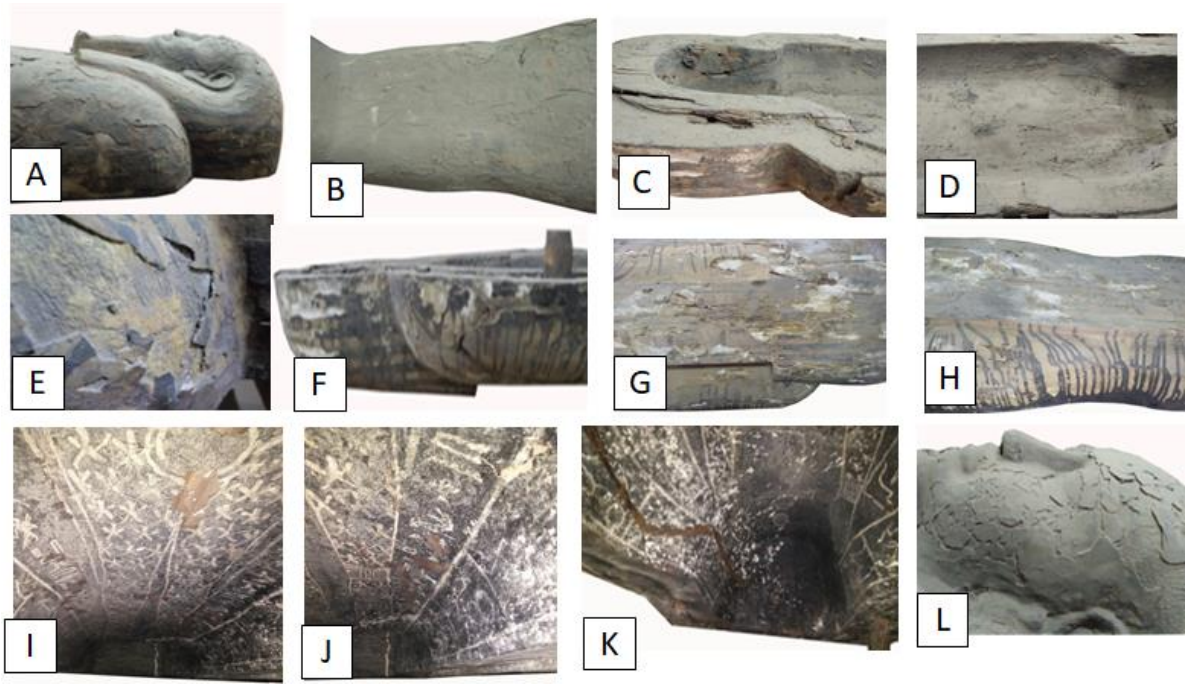

Fig. 1. Aspects of deterioration of the studied coffin; A-D) Dust ; E-H) Missing parts; I-K) White powder; L) Dust and missing parts.

3.2. *Documentation of the decoration on the black resin layer by 2D program*

Adobe Illustrator was used to highlight the decoration of the black resin layer on the cover of the coffin (Fig. 2.). This facilitated the interpretation of the decoration, allowing for the identification of the name of the deceased on the coffin. " It was found out that the coffin belonged to Psamtik Sinb “the son of an army chief in the Late Period”. There were 12 Gods on the right side and the same number on the left side, indicating the number of hours of the day and the night.

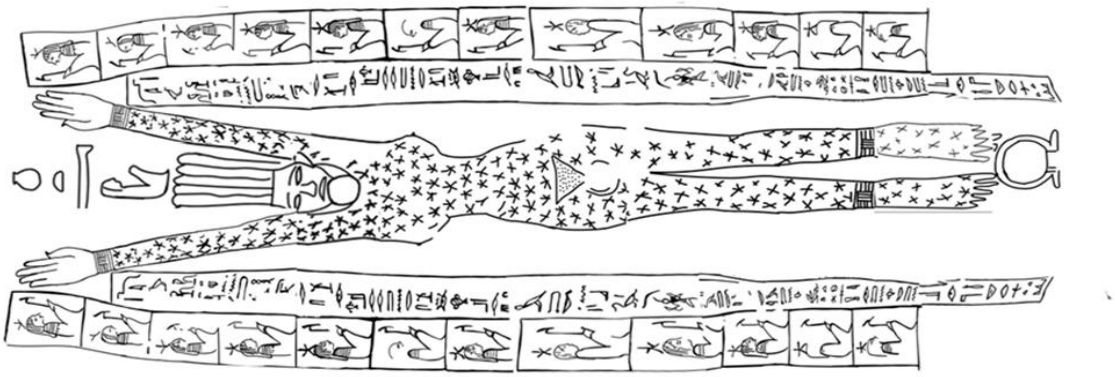

Fig. 2. 2D documentation of the decoration inside the lid of the coffin.

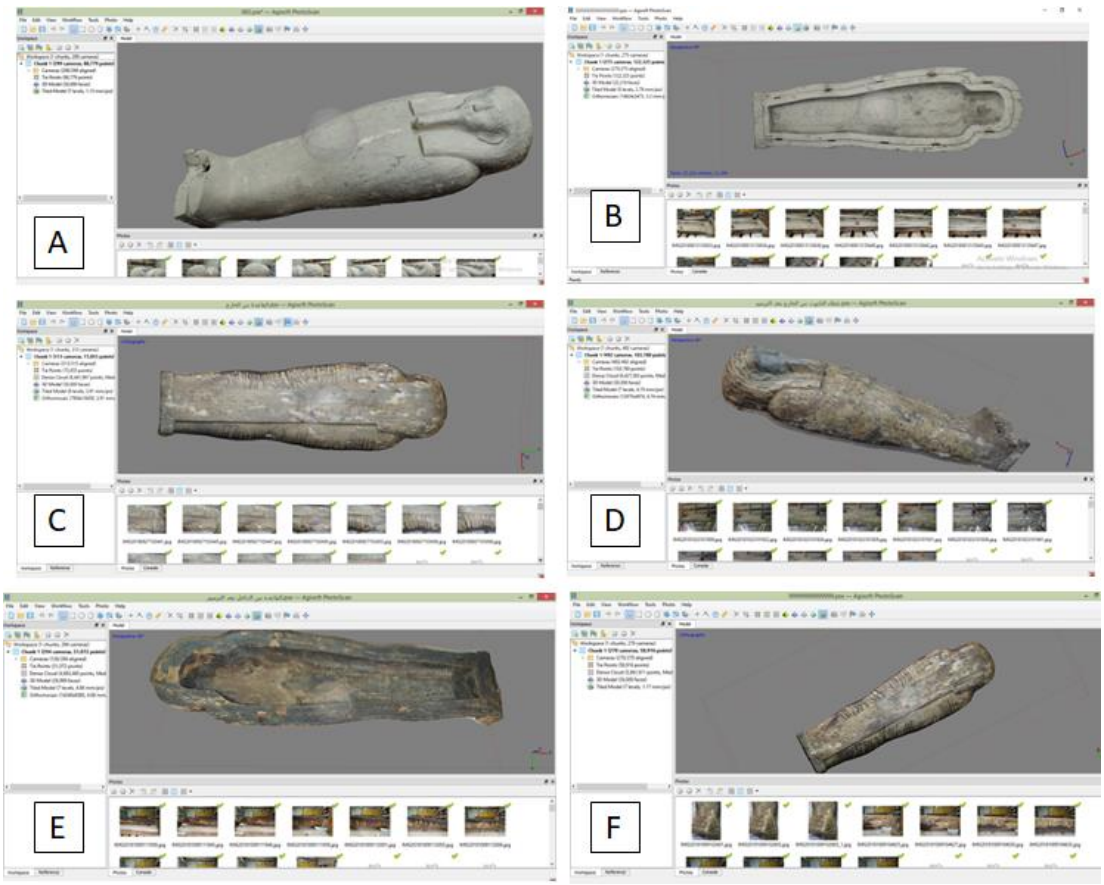

Fig. 3. 3D model of the coffin: A-C) Before conservation; D-F) After conservation.

3.3. Photogrammetric documentation

A 3D model of the coffin was made prior to conservation (Fig.3. A-C), and after conservation (Fig. 3. D -F).

3.4. Measuring moisture content

The measured moisture content of the wooden coffin (Fig.4. A,B) was very important for assessing its condition and selecting the best material for the conservation process.

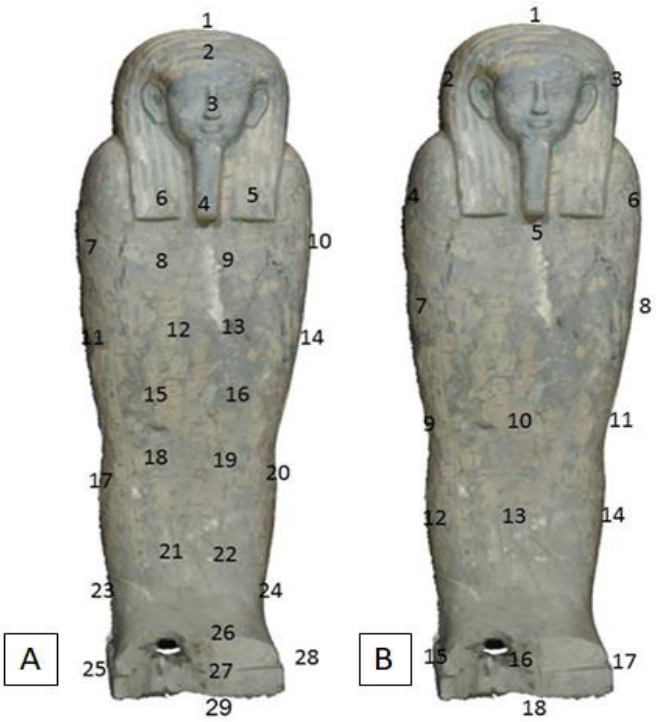

Fig.4. Moisture content and temperature measurements on the coffin; A) The positions of the moisture content; B) The positions of temperature measurement.

Table 1. Moisture content inside the wooden coffin.

No.	Moisture content (%)	Temp (°C)	No.	Moisture content (%)	Temp (°C)
1	7.6	20	16	10	23
2	8.8	24	17	9.4	30
3	4.4	29	18	10.4	30
4	7	22	19	10.4	--
5	8.8	22	20	8.8	--
6	8.8	28	21	7	--
7	7	24	22	10.8	--
8	9.4	31	23	10	--
9	9.4	28	24	11.6	--
10	8.2	27	25	10	--
11	9.4	24	26	10.4	--
12	9.4	22	27	10.8	--
13	7	31	28	10.4	--
14	7.6	26.4	29	12.6	--
15	8.8	30		--	--

(Table 1.) shows that the water content of the coffin was less than the water content of the wood because the moisture content of the wood is (14%) and coffin was kept in a desert area (Saqqara- Egypt). The moisture content in archaeological wood is known to be a certain percentage. However, for coffins, it varies because they are kept in a desert area. The water content percentage differs from one coffin to another based on the storage environment.

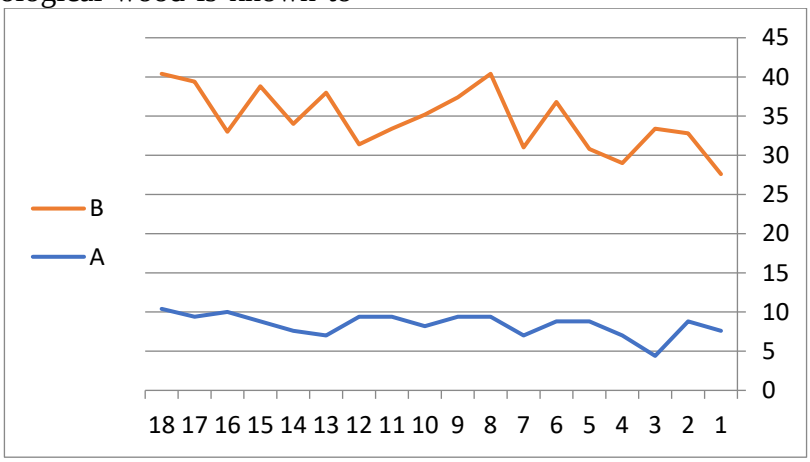

Fig. 5. Moisture content of the coffin: A- Moisture content on the coffin in percentage; B -Temperature of the coffin.

3.5. Measuring the temperature of the wooden coffin

The temperature and relative humidity of the surrounding environment were measured. Additionally, infrared (IR) [20] was used to measure the temperature of the coffin (Fig.5.). The temperature of the surrounding environment was 35 % and Relative humidity 36.7 %.

The temperature and relative humidity of the surrounding environment were measured. Additionally, infrared (IR) [20] was used to measure the temperature of the coffin (Fig.5.). The temperature of the surrounding environment was 35 % and Relative humidity 36.7 %.

The temperature of the environment surrounding the coffin varies throughout the day. When work begins in the restoration laboratory, the doors are open, resulting in a lower temperature. Once the laboratory is closed after work, the temperature gradually rises and then decreases again at the end of the day, leading to temperature fluctuations. The surrounding humidity increases the expansion and contraction of the wooden support, the ground layer, and the pigment, contributing to damage and deterioration.

3.6. Treatment and Conservation

The conservation of the coffin has great importance to the future generations [21]. The conservation treatment included documentation, mechanical and chemical cleaning, consolidation, reattachment of the ground layer to the support, and filling the edges of the ground layer.

3.6.1. Mechanical cleaning

Cleaning is one of the most complex and delicate steps in a restoration process.

The dust on the surface and base of the coffin was removed using soft brushes and a rubber air blower pump (Fig. 6. A,B.).

3.6.2. Chemical cleaning

Because previous conservation materials included beeswax and poly (vinyl acetate), therefore, ethyl alcohol and distilled water (1:1) were used for chemical cleaning (Fig. 6. c.). After conducting several tests, it was decided to opt for chemical cleaning of the painted layer. Xylene and distilled water (1:1) were used for the chemical cleaning of

the black resin layer (Fig. 6. D, E.). There was a remarkable change to the appearance of black resin layer before and after chemical cleaning (Fig. 6. F.).

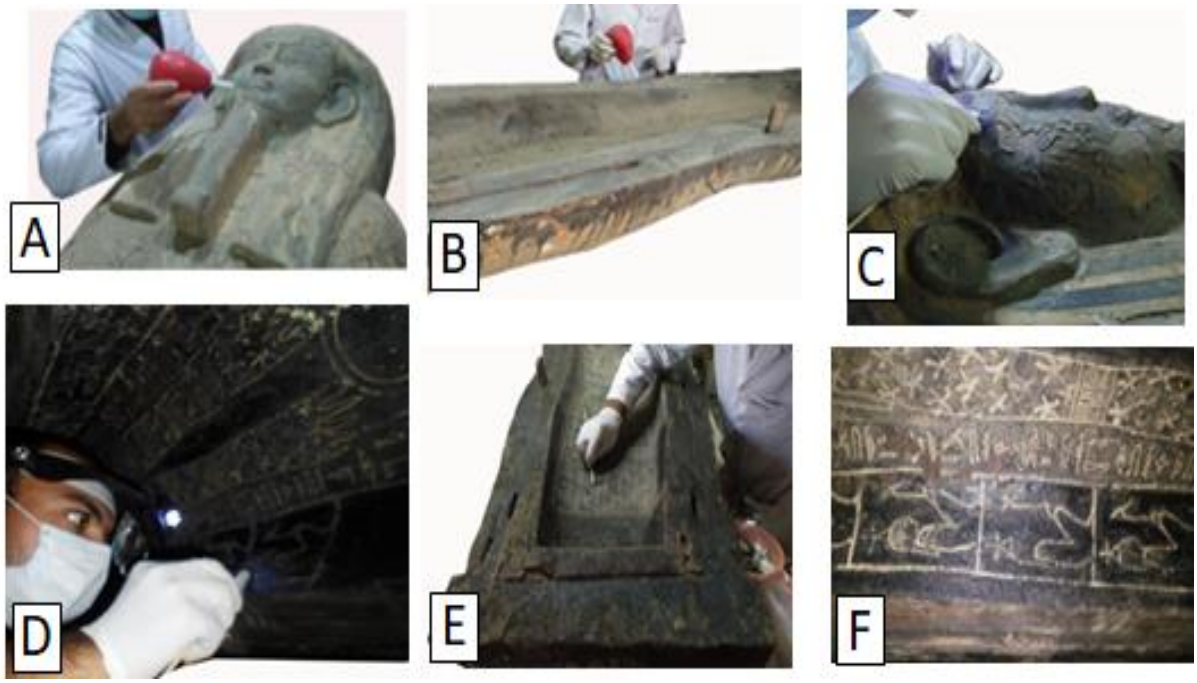

Fig.6. Mechanical and chemical cleaning of the wooden coffin; A, B) Mechanical cleaning; C-F) Chemical cleaning of the black resin and painted layer.

3.6.3. Stabilization of the separated painted gesso layers

Primal AC33 was used for the stabilization of the separated painted gesso layers [22]. A solution of 10 % Primal AC33 was used for the reattachment of the separated parts to the wooden support by injection (Fig. 7. A, B.). Solutions of Klucel E (hydroxypropyl cellulose) 0.5% W/V in ethyl alcohol was adopted for the consolidation of the painted layer because of its good penetration.

It was very difficult to remove previous conservation materials because they were embedded in the paint surface and wood substrate, they could not be removed without damage to the original surface [23].

3.6.4. Filling the edges of the ground layer

3M™ Glass Bubbles were mixed with paraloid B72 in acetone at a 15% w/v concentration and applied using a spatula. Natural earthy oxide colors, similar to those used by the ancient Egyptians, were applied to the micro-balloons (Fig. 7. C-E; Fig. 8. A-D; Fig. 9. A,B). Cracks were filled with glass micro-balloons, and the edges of the micro-balloons were colored to match the original color as closely as possible [24-26].

3.6.5. Consolidation of the black resin layer

Soft brushes were used to apply Nano Paraloid B72 in xylene 1.5% for consoled-ating the black resin layer (Fig.7. F) (Fig.8. E-H) (Fig.10. A,B.) [27, 28].

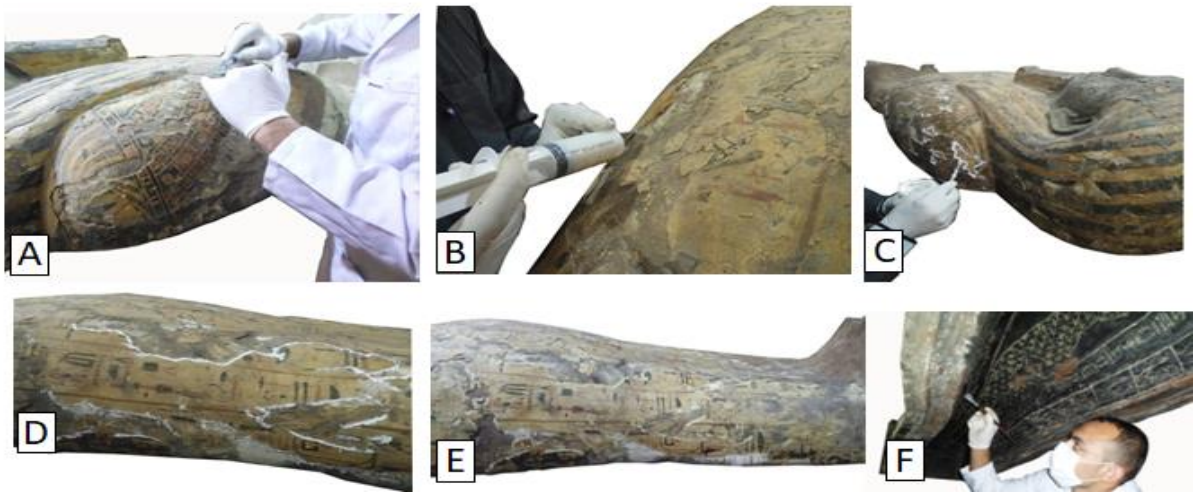

Fig. 7. Restoration process; A, B) Reattachment of the gesso painted layer; C, D) Filling cracks with glass microballoon; E) Coloring the edges of micro-balloon; F) Consolidating the black resin layer.

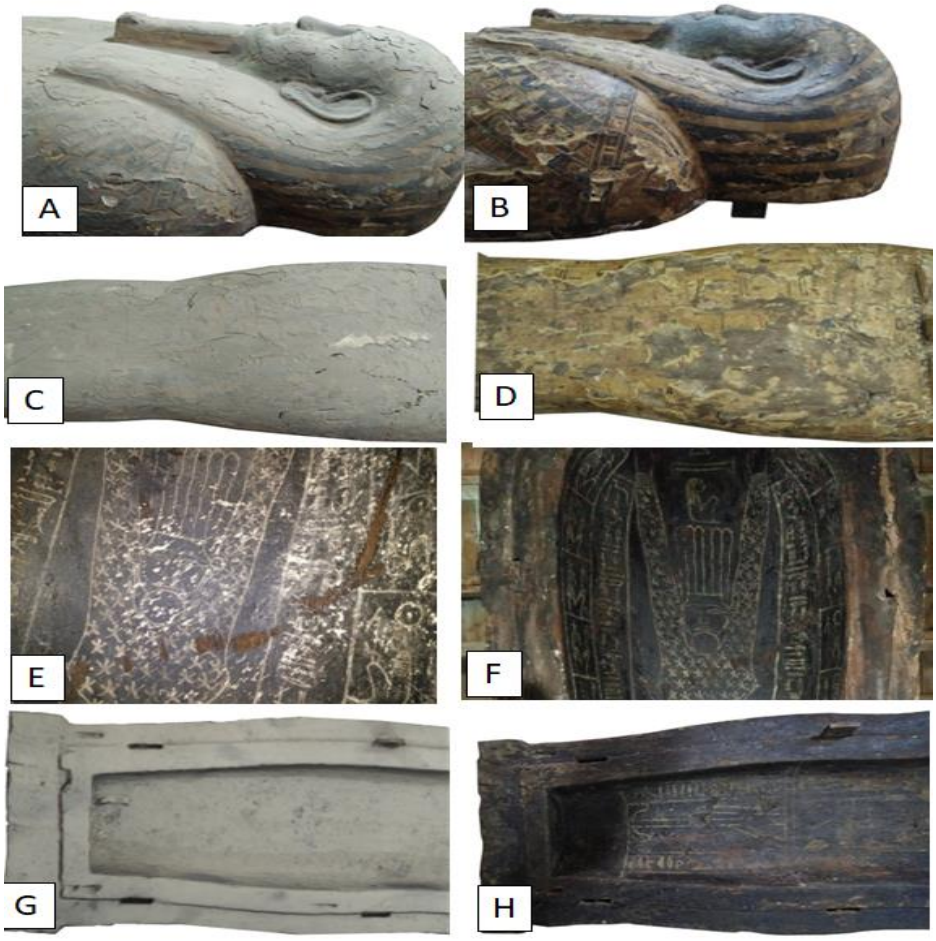

Fig. 8. Parts of the coffin before and after conservation treatment; A-D) The lid from outside before and after conservation; E-F) The lid of the coffin from inside before and after conservation; G-H) The base of the coffin from inside before and after conservation.

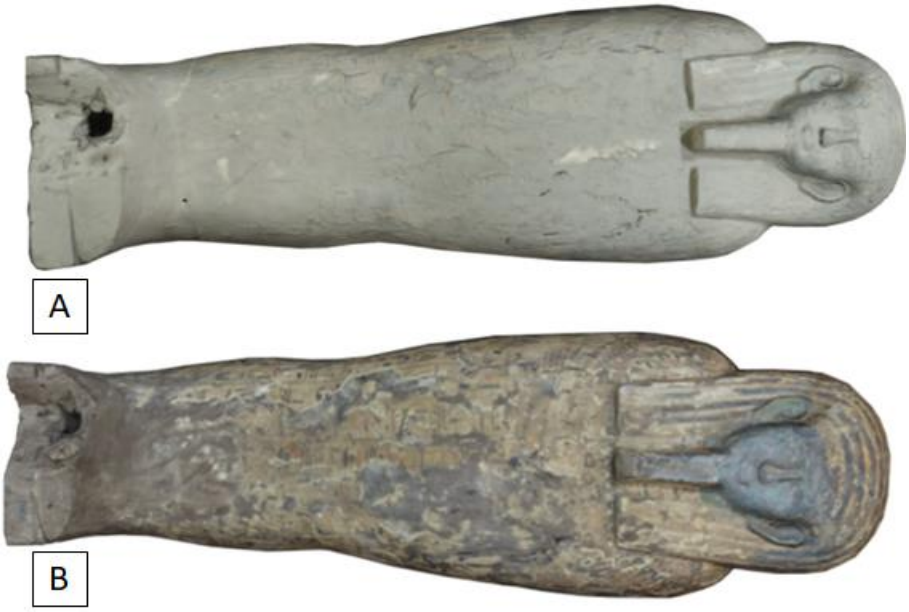

Fig. 9. The lid of the coffin; A) Before conservation; B) After conservation.

Fig. 10. The base of the coffin; A) Before conservation; B) After conservation.

4. Conclusion

The coffin suffered significant degradation, with various aspects of deterioration observed, most likely due to poor storage and previous conservation techniques. Therefore, a 2D program was utilized to document and illustrate the decoration of the black resin layer, and a 3D program was used to create a 3D model of the coffin before and after conservation. Primal AC33 were applied for the reattachment of the ground layer, while a mixture of micro-balloon, Paraloid B72 and earth pigments were used to maintain the edge of ground layer. Klucel E was used for consolidating the painted layer, and Nano Paraloid was used for consolidating the black resin layer.

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