

# THE CONSERVATION OF TUTANKHAMUN'S LEATHER SCALE ARMOUR

BY

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## ABSTRACT

**[AR]** تحديد وكشف لطرق صناعة درع توت عنخ آمون ذو القشور الجلدية بمساعدة عمليات الترميم يتناول هذا البحث ويكشف عن تقنيات صناعة الدرع الجلدي ذو القشور الخاص بتوت عنخ آمون. كان هذا الدرع في حالة حرجة وخضع للعديد من إجراءات الترميم. وقد عانى هذا الدرع من بعض مظاهر التلف الخطيرة مثل: التحطم إلى أجزاء، حيث عثر على كثير من القشور الجلدية مبعثرة في صندوق ومنفصلة عن الحامل الكتاني للدرع، مما جعل الحدود الخارجية لهذا الدرع مهمة وغير مفهومة. لذلك كان الدرع في أمس الحاجة للتدخل بالترميم وإعادة البناء. تم إجراء بعض عمليات التوثيق قبل البدء بإجراءات الترميم. تم تطبيق كثير من إجراءات الترميم القابلة لإعادة المعالجة على الدرع سعياً لتحقيق استقرار في حالة الدرع والوصول إلى حالة مستدامة. وتضمنت عمليات الترميم العديد من الفحوص والتحليل التي ساعدت في الكشف عن المواد والتقنيات الصناعية المستخدمة في تصنيع هذا الدرع. درع توت عنخ آمون ذو القشور الجلدية يتكون من مجموعة من القشور المتصلة بحامل كتاني. يتكون هذا الحامل من عدة طبقات. افترض هوارد كارتر أن هذا الحامل الكتاني يتكون من 6 طبقات. ساعدت عمليات الترميم المختلفة على الكشف عن العدد الحقيقي للحامل الكتاني إلى جانب الوصول لأفضل حالة من الإستقرار. يهدف هذا البحث إلى تناول أهمية إجراءات الترميم المنفذة في تحديد و الكشف عن المواد المستخدمة في تصنيع الدرع الجلدي القشري.

**[EN]** This paper discusses and views the conservation procedures of the leather scale armour of Tutankhamun, which was in a critical condition and many conservation procedures had to be conducted. The armour suffered from some serious deterioration aspects, such as fragmentation, losing of its original shape, its parts were scattered inside the box and separations from the linen support. The armour needed conservation and reconstruction. Some conservation treatments and materials were chosen carefully after their evaluation. Documentation measures were done before conservation. Several reversible conservation procedures were applied on the armour to reach stabilization and sustainable condition. The conservation treatments included many investigations and analyses that helped revealing materials and techniques of the making of the armour. The leather scale armour of Tutankhamun consisted of leather scales attached to a linen support of several layers. Howard Carter assumed that the linen support consisted of 6 layers, yet recent conservation treatments revealed that the linen support consisted of 12 layers in the upper part near the suspenders, 6 in chest area, and 3 in abdominal area. UV imaging of the scale armour was achieved to test if the armour was involved in any actual battle or war. This paper aims to view the importance of conservation procedures in identifying and revealing all materials used in manufacturing the leather scale armour.

**KEYWORDS:** Consolidation, scale armour, investigations, reconstruction, sustainability.

## I. INTRODUCTION

The leather scale armour of king Tutankhamun is dated back to the New kingdom. After discovering the hidden tomb of king Tutankhamun in 1922 by Howard Carter<sup>1</sup>, all findings were well documented, photographed, and treated before their transfer to the Egyptian Museum in Tahrir. However, the previous conservation procedures and storage conditions caused massive damage to the sensitive organic materials of the scale armour.

According to the Howard Carter archives, the Griffith Institute, the cuirass was described as follows «a leather cuirass upon linen support, crumbled up and cast into the box». He recounted the details of the cuirass «leather attachment to linen support, leather straps holding the leather scales in place, linen support comprises six folds of linen, red leather, the scales in the various rows range from 2.3 to 5.3 cm in length, ridge». According to Alfred Lucas, the armour was treated *in situ* before its transfer; he mixed equal quantities by volume of amyl acetate and acetone, after that he added 2.5% sol. of Celluloid<sup>2</sup>. Finally, he added pure castor oil, shooked it well and treated the cuirass with the final material. The previous conservation materials used in hot state caused carbonization of many leather pieces and parts of linen support<sup>3</sup>. Therefore, conservation procedures of the armour had to be applied. Deciding the suitable conservation procedures, techniques, and materials was essential. It's well known that various conservation materials and techniques are suitable for specific cases. For instance, for the mechanical cleaning for leather, Storch suggested using vacuum brushes or sponges for cleaning and removing fine dust. He warned of the damage that dry brushes could cause during cleaning as this method could be abrasive to the delicate surface<sup>4</sup>. Moreover, the Canadian conservation institute 1992, recommended using soft brushes for removing dust and dirt particles with vacuum nozzle held to suck dust from a safe distance<sup>5</sup>. Kite recommended using Paraloid B67 in white spirit or Klucel G for consolidating severely damaged leather or to clean damaged leather surface<sup>6</sup>. Kite and Thomson suggested using Crepeline and Lascaux 498 in supporting damaged textiles<sup>7</sup>. Crepeline is ideal for supporting textiles as it becomes almost invisible after treatment. Some researchers recommended the use of Beva 371 (solution and film) solution visually and manually, and the results were excellent<sup>8</sup>. Calnan recommended using Beva (solution and film), among other consolidation materials, for supporting textiles and leather. He noticed that the Beva sheet applied with heat stronger in bonding than the wet treatment<sup>9</sup>. Cser stated that the lining system for textiles included the presence of Beva gel and Beva 371 film, provided a

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<sup>1</sup> VELDMEIJER 2021: 125.

<sup>2</sup> TUTANKHAMUN: ANATOMY OF AN EXCAVATION 2022.

<sup>3</sup> CANADIAN CONSERVATION INSTITUTE 1992: 2; SUBOOHI & ABDURAHEEM 2021: 1109.

<sup>4</sup> STORCH 1987: 2.

<sup>5</sup> CANADIAN CONSERVATION INSTITUTE 1992: 2.

<sup>6</sup> KITE & THOMSON 2006: 122.

<sup>7</sup> ABDEL KAREEM 2021: 13.

<sup>8</sup> KRONTHAL et Al. 2003: 354.

<sup>9</sup> CALNAN 1991: 46.

stable and multi-function treatment. He added that these materials provided minimal visual interference<sup>10</sup>.

The researchers chose the suitable treatments for the leather scale armour according to the current condition and the most appropriate materials and methods, which provided sustainable and durable. Some leather scales were found glued to each other due to the chemical reaction between conservation and tanning materials. This reaction formed a white layer on leather. Overall, previous conservation caused color changes. The scale armour suffered from other deterioration aspects, such as dust due to long storage period [FIGURE 1]. The most critical aspect was the rotten smell on the scale armour arising from its storage in high relative humidity, which led to microbiological infection<sup>11</sup>.



[FIGURE 1]: The scale armour before conservation© Photo taken by S. Mohamed

## II. RESEARCH OBJECTIVES

This research aims to recover the original shape of the leather scale armour of Tutankhamun by the application of some selected conservation procedures, as well as revealing the manufacturing techniques of the armour. Furthermore, the paper aims to ensure the importance of conservation applications in reaching the most sustainable condition of Tutankhamun's scale armour.

## III. MATERIALS AND METHODS

This paper aims to view conservation procedures for a critical case, the leather scale armour of Tutankhamun. Some conservation treatments and materials were chosen carefully and were undertaken and evaluated. The investigations and analyses applied in this study helped in revealing information about the leather scale armour, and identify previous conservation materials used on leather. The UV imaging of the scale armour was conducted to test if the armour was involved in any actual battle or war. The documentation and conservation study of King Tutankhamun's war cuirass, poster in the 43<sup>rd</sup> annual meeting of the American Institute for Conservation»<sup>11</sup>. IR imaging was executed to study the surface morphology and to assess the current condition. Isolation

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<sup>10</sup> CSER 2003: 3-5.

<sup>11</sup> MOHAMED 2016: 5.

and identification of microorganisms was executed on the armour due to the presence of bad odour<sup>12</sup>.

The FTIR spectroscopy indicated the presence of previous conservation materials. Investigations with Digital Microscope were applied to identify materials and techniques used in making the armour. The conservation procedures applied on the leather scale armour included the following mechanical cleaning by using soft brushes, chemical cleaning by using isopropyl alcohol.

A facing of Japanese paper and Klucel G 1% was made to separate leather scales previously stuck together inappropriately from the textile. Straightening of the linen support was conducted by using ultrasonic steam cleaner. The consolidation of the linen support was applied using a Crepeline textile with liquid Beva dissolved in Toluene. Reconstruction and re-arrangement of the leather scales were executed by Crepeline textile adhered over Beva 371b film on some points at 60° C. Conservation, investigations, and analyses were executed at the Conservation Centre of the Grand Egyptian Museum.

#### IV. INVESTIGATIONS AND ANALYSIS

##### 1. UV Imaging

This method uses UV lamp, diode, or LED. Emission is directed to the object, then the reflected UV light was captured by digital camera. Features and characteristics can be observed due to unique interaction between ultraviolet light and materials. In this process, UV light is not altered or converted by any mean. The surface topology can be visualized due to the absorption of UV by many materials without the need for light penetration<sup>13</sup>. Imaging with UV is used in detecting unseen details with naked eye. Traces of blood or scratches by weapons can be recognized by this method in addition to the detection of previous conservation materials like consolidation materials [FIGURE 2].

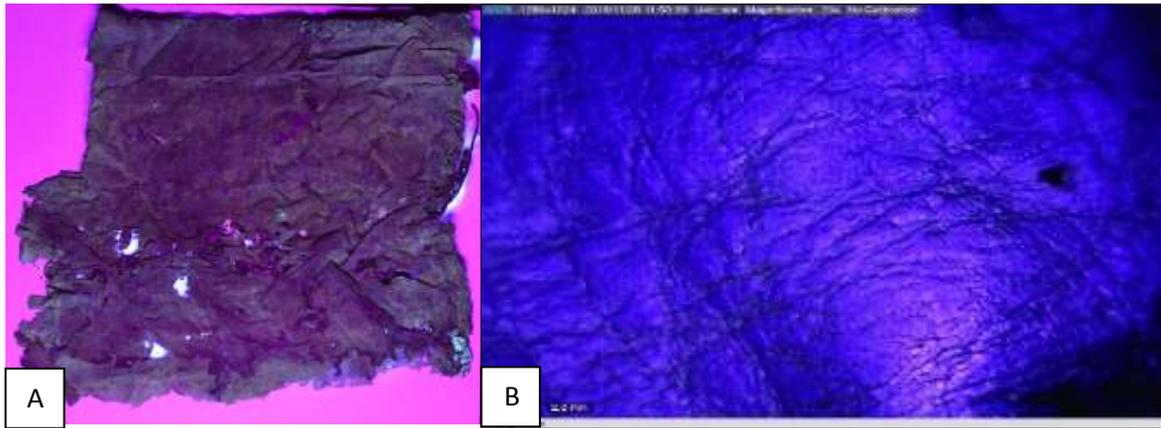
##### Results

UV imaging proved that neither blood stains nor weapon strikes were found on any part of the leather scale armour denoting that this scale armour was not involved in any actual battle or war.

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<sup>12</sup> TANKESHWAR 2022: 1-2.

<sup>13</sup> «ULTRAVIOLET IMAGING», in: <https://midopt.com/solutions/monochrome-imaging/ultraviolet-imaging/>, Accessed on 17/11/2022



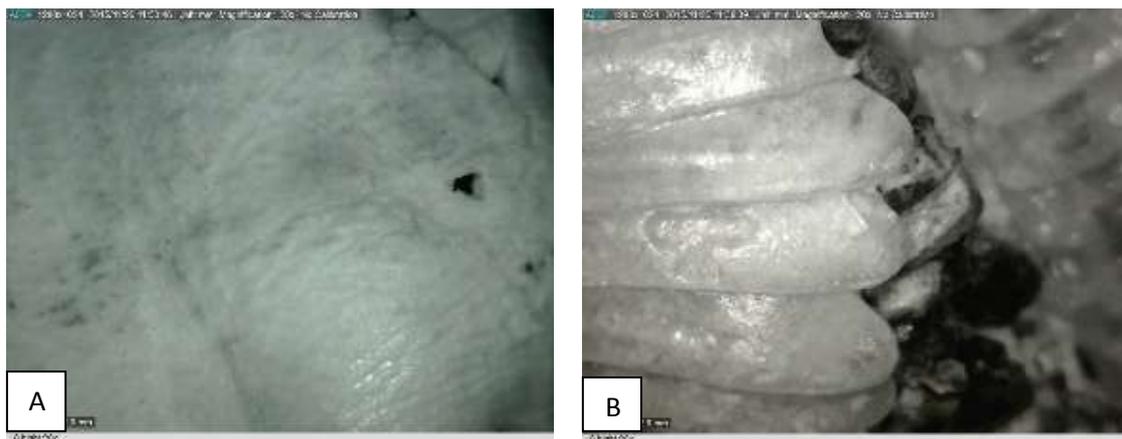
[FIGURE 2]: UV imaging of the different parts of the cuirass looking for traces of blood or strikes of weapons. A. The linen support, B. The inner leather part of the armour © Photos taken by S. Mohamed

## 2. Infra-red Imaging

The wavelength of the light is between 700–900 Nano meters. Mainly, this method is used to reveal hidden features unseen by naked eye. Special filters are used to detect hidden features. This investigation was applied in order to study the surface morphology of the leather parts and to assess the current condition. Infrared imaging helps in identifying surface defects, such as cracks, tears, or holes<sup>14</sup>. These defects may not be visible to the naked eye [FIGURE 3].

### Results

Infra-red imaging revealed tiny cracks and holes on the leather scales due to dryness. The surface was even in color; no stains were found on leather indicated that the tanning materials were distributed evenly on leather surface.



[FIGURE 3]: Infra-red imaging to study the surface morphology and assess the current condition, A. The inner leather part of the armour, B. leather scales © Photos taken by S. Mohamed

<sup>14</sup> TUCKER 2023: 1-2.

### 3. Isolation and Identification of Microorganisms

Because of the bad odour emitted from the scale armour, it was necessary to check for microbiological infection as a cause [FIGURE 4]. Several swabs were taken from all different organic components of the scale armour (leather and textile) as follows:

**Swab (1):** From the white area in the linen. **Swab (2):** From the brown spot in the linen.

**Swab (3):** From the green spot in the leather. **Swab (4):** From the internal area between linen and leather. **Swab (5):** From the black resin in the separated part. **Swab (6):** From the reverse.

Additionally, an air sample was taken from the surrounding air. The examination and interpretation of fungi was conducted by morphological characters. Macroscopic morphological features included the color, texture and diameter of colonies<sup>15</sup>. Bacteria were identified by cell stain gram according to Bergey's manual<sup>16</sup>.

#### Results

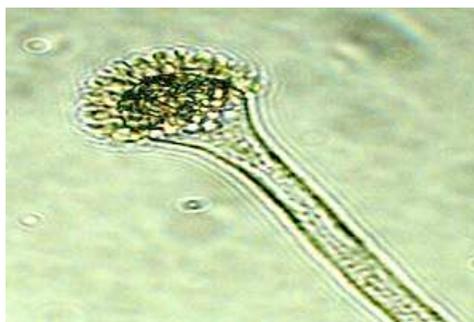
The results confirmed a positive fungal and bacterial infection in all previous swabs. Three fungi types were identified; *Aspergillus*, *Fusarium*, and *Penicillium*. Bacterial infection was found in the first three swabs, *gram +ve cocci* and *gram -ve bacilli*, [FIGURES 5-8]. The object was mechanically cleaned and then treated.



[FIGURE 4]: Some microbiological swabs were taken for testing, A. Swab from the linen part, B. Swab from the leather part © Photos taken by S. Mohamed

<sup>15</sup> SENANAYAKE 2020: 2678.

<sup>16</sup> BOONE & CASTENHOLZ 2001: 24.



[FIGURE 5]: *Aspergillus flavus* (500X)



[FIGURE 6]: *Aspergillus niger* (500X)



[FIGURE 7]: *Fusarium* sp.(500X)



[FIGURE 8]: *Penicillium* sp.(500X)

©Done by S. Mohamed

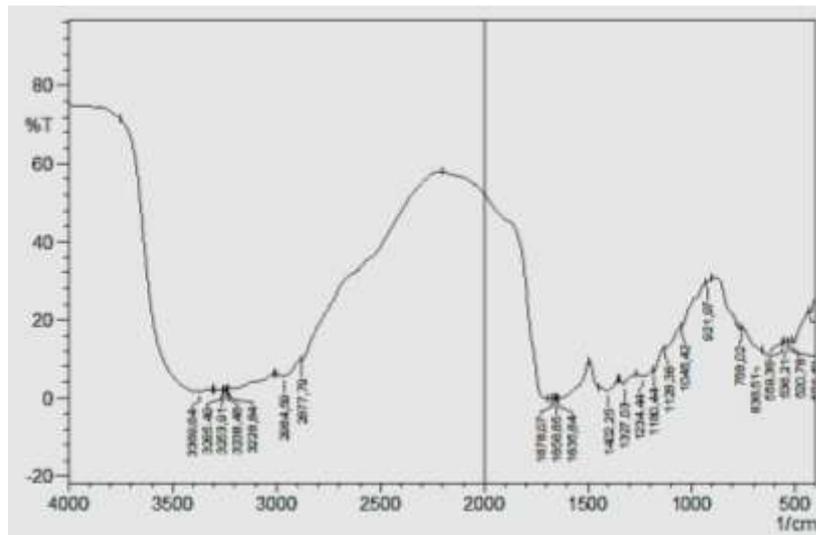
#### 4. Fourier Transform Infrared (FTIR) Spectrum

KBr technique was used for sample preparation. The spectrum was measured at a resolution of  $4\text{ cm}^{-1}$ , and 20 scans were recorded per sample. IRPrestige-21 FTIR Spectrometer and the IR solution software were used. Spectrum in the  $4000\text{-}400\text{ cm}^{-1}$  range was baseline corrected, and atmospheric compensation was conducted. The black sample from the scale's surface indicated the presence of Celluloid, which had been used in the previous conservation and was in a brittle condition<sup>17</sup> [FIGURE 9].

#### Results

The FTIR spectroscopy indicated the presence of Celluloid on leather scales as a previous conservation material.

<sup>17</sup> BERTHOMIEU et Al. 2009: 164.



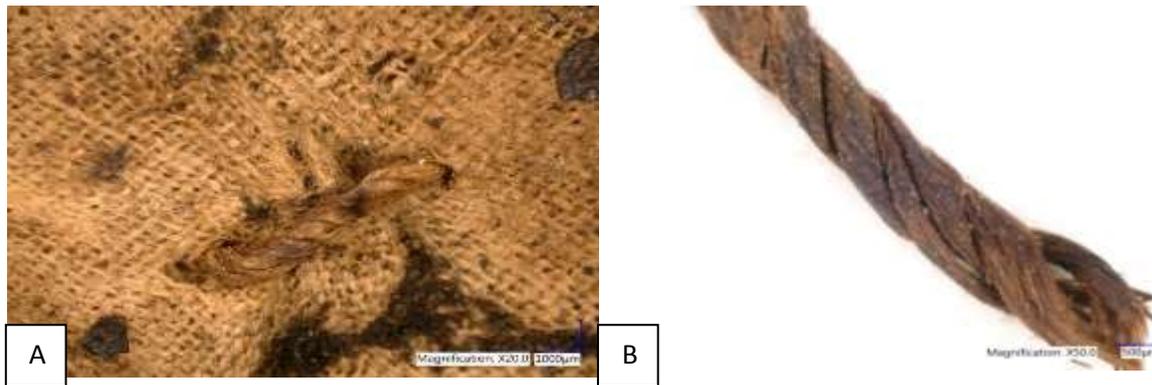
[FIGURE 9]: FTIR chart of the tested sample © Photo taken by S. Mohamed

## 5. Investigations with Digital Microscope

This investigation method is applied to identify materials and techniques used in the making of the armour before conservation in order to determine the suitable materials for conservation. AVHX- 900F Digital microscope with a progressive scanning system, a frame rate of fps (max) and a 1/1.81\_8- inch CMOS image sensor was used. Due to the fact that the scale armour had textiles as one of its components, it was important to identify the type of fibers used besides the manufacturing technique with the digital microscope; two samples were imaged.

### Results

Examining the first sample with the digital microscope confirmed that linen was used in making the textile. The manufacturing technique was a plain weave . The second sample identified indicated that another type of plant was used as threads for fixing leather scales on the textile support. These threads were made of halfa grass [FIGURE 10].



[FIGURE 10]: A. Linen textile method 1:1 plain weave, B. Traces of halfa grass threads on linen textile under microscope which bind leather scales with the textile support © Photos taken by S. Mohamed

## V. CONSERVATION PROCEDURES

### 1. Mechanical Cleaning

It was crucial to start with the mechanical cleaning as the scale armour was covered with dust and dirt on leather scales and textile. The mechanical cleaning was applied by using soft brushes to reduce friction with the fragile parts. The cleaning started from the middle to the edges to remove dust particles away from the scale armour. The leather scales were lifted from the textile during cleaning to reach parts beneath them and because they had been placed in the wrong order [FIGURE 11].



[FIGURE 11]: The process of mechanical cleaning applied by using soft brushes © Photo taken by S. Mohamed

### 2. Chemical Cleaning

As previously explained, the scale armour had been treated and conserved with a high concentration of celluloid and paraffin wax at high temperature near boiling point. This led to severe distortion of the leather scales which was attached to each other and had deteriorated. The hot application of the previous treatment had formed a thin white layer. Therefore chemical cleaning was foremost to reveal the actual color of the leather scales. For chemical cleaning Isopropyl alcohol was

applied on previous conservation materials spots only and removed mechanically<sup>18</sup>.

### 3. Separating Leather Scales Attached Incorrectly

For this purpose, a protective «facing» layer for the leather scales from face side was necessary. This layer was applied with Japanese paper and Klucel G 1%<sup>19</sup>. Then, the scales were separated safely from textile. After finishing mechanical and chemical cleaning for the scale armour, the scales were supported from the back with Crepeline made of 100% natural pure silk fabric adhered with a Beva 371 film by heat [FIGURE 12].



[FIGURE 12]: The separation process of leather scales attached together incorrectly  
© Photo taken by S. Mohamed

### 4. Straightening the Linen Support

After examining textile, it was found that the scale armour consisted of six layers in chest area and three layers in stomach area. The straightening process was difficult because each textile layer had to be straightened individually. Ultrasonic steam cleaner was used with wooden spatula and glass weights to ensure the process. The ultrasonic steam cleaner consisted of an ultrasonic humidifier with regulated steam and humidity. Steam spray gun with hose beside a control unit with controller of temperature were used<sup>20</sup>. After the total straightening of the textiles, the maximum length is 42 cm, and the maximum width is 44 cm [FIGURE 13].

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<sup>18</sup> HASSAN 2019: 224.

<sup>19</sup> HORIE 2010: 8-9.

<sup>20</sup> «Ultrasonic Steam Cleaner Mod. Steam Scalpel», in: <https://www.ctseurope.com/gb/515-ultrasonic-steam-cleaner-mod-steam-scalpel>, Accessed 12/10/ 2022



[FIGURE 13]: The straightening process, A. Using glass weights in the straightening process, B. The use of Ultrasonic in humidifying and straightening of the textile © Photos taken by S. Mohamed

## 5. Consolidation for the Linen Textiles

After the total straightening of linen support, the consolidation process was applied using Crepeline textile with 10% liquid Beva dissolved in Toluene v/v. The Crepeline was loosely woven, silk was used as a backing support for fragile textiles. The Beva solution was applied on Crepeline textile by brushing technique. After total dryness, the Crepeline was added to the textile from backside and fixed in several points with thermal spatula and thermal paper in between to prevent any thermal damage<sup>21</sup>.

## 6. Reconstruction and Re-arrangement of Leather Scales

After the total strengthening of the linen textiles, the leather scales were divided into four groups:

1. Leather scales of chest area-
2. Leather scales of the straps-
3. Leather scales on shoulders-
4. Leather scales under the straps.

The leather scales were not fixed to textiles in their places by old holes due to fragility and weakness. Add to that, the leather was saturated with previous conservation materials, and the pores were blocked. Therefore, the leather scales were fixed to textile using Crepeline adhered over Beva 371b film on some points at 60°C for few seconds with the use of silicone paper [FIGURE 14]. After putting the scales back in their places, the facing was removed from surface by Ethyl alcohol<sup>22</sup>.

<sup>21</sup> KRONTHAL et Al. 2003: 359.

<sup>22</sup> KRONTHAL et Al. 2003: 360-362.



[FIGURE 14]: Fixing leather scales arrangement by using Beva 371b film with Crepeline prior to fixing them on the linen support © Photo taken by S. Mohamed

The treatment with Beva 371 and heat on leather was previously examined and evaluated by other researchers. Kite mentioned using Beva 371 film with heat treatment at 70-75° C for a fragmented ermine fur lining of a cape, as well as a pair of fine Suede gloves which gave convenient results<sup>23</sup>. Sturge reported heat set treatment using the Beva 371 film for torn stitching within a saddle<sup>24</sup>. Additionally, Forest noticed that Beva 371 bonds instantly once the temperature reached 60° C and for very short time<sup>25</sup>. After finishing the conservation procedures, the leather cuirass reached a stabilised condition [FIGURE 15].



[FIGURE 15]: The scale armour after conservation © Photo taken by S. Mohamed

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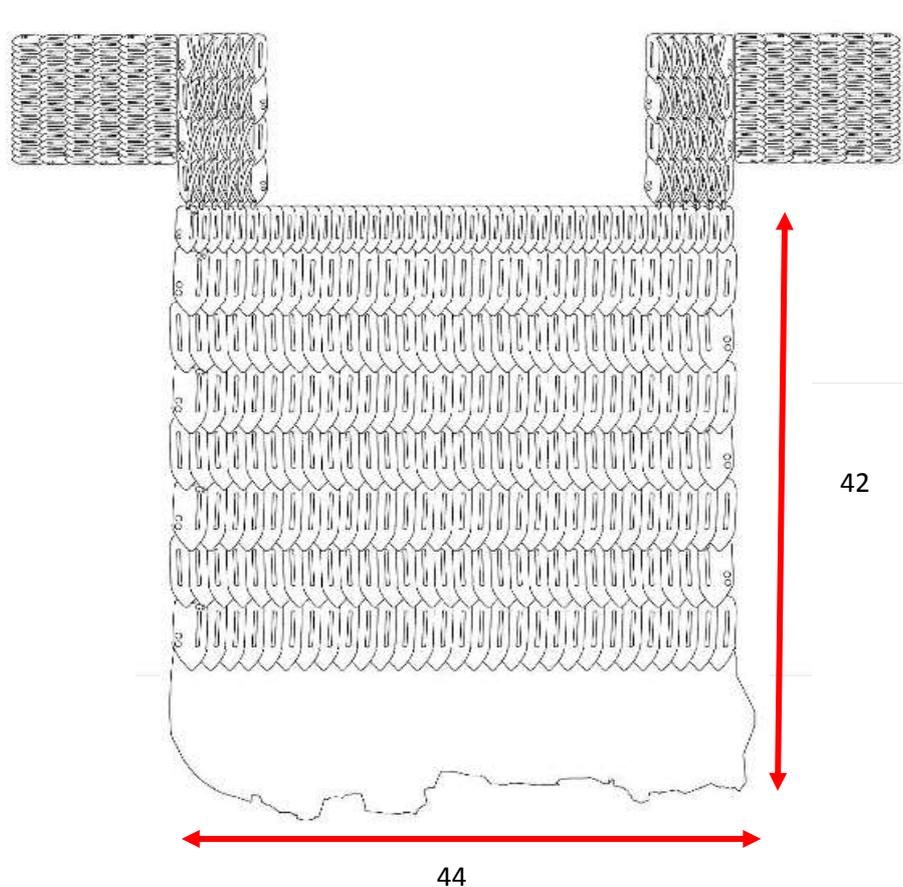
<sup>23</sup> KITE 1990: 620.

<sup>24</sup> STURGE 2000: 65.

<sup>25</sup> FOREST 1997: 47-49.

## Measuring Cuirass after Conservation

After finishing conservation procedures and putting leather scales in their right places, measurements of the cuirass were taken. The length and the width of the cuirass were measured and documented by Auto Cad drawing [FIGURE 16]. Scales of the chest area were measured after conservation and placing each scale in its place. The linen support was measured after flattening and understanding the folding technique of linen support. The folds were measured, and the leather scales to the back of armour and shoulders were measured too.



[FIGURE 16]: An Auto Cad drawing of the scale armour showing the method of row arrangement of leather scales and number of used scales © Photo taken by S. Mohamed

## 7. Revealing Manufacturing Techniques

After the complete conservation of the cuirass, it was clear that length of linen support is 41 cm, the width is 45 cm and it was divided into 2 areas. The first area is the chest area which consisted of 6 layers made of linen with 17 cm length and 45 cm width. The other area was the stomach area which consisted of 3 layers. The extra layers in chest area were added to reduce the impact of hitting force by weapons which could be lethal, causing bone breaks or death. The leather scales put on each other were enough to prevent

weapons from breaking through the cuirass. The leather scales were divided into four different sizes on the cuirass; the chest area consisted of two different sizes, the leather straps in shoulder area, the shoulder decoration area type and the back side. The leather scales were fixed together in a row and fixed on the linen support in 9 main points. Leather scales fixed on the surface were not fixed individually, but each two rows were fixed together on the linen support in only nine points mutually. The distance between the first fixing point of the leather scales and the second fixing point was 7 cm, while the distance between the second fixing point and the third fixing point was 11 cm and the distance between the third fixing point and the fourth point was 7 cm. The distance between the fourth fixing point and the fifth point was 11 cm. This is an indicator that the first row of leather scales was fixed on the linen support while the second row of leather scales was not fixed on the linen support but fixed on the previous row. The third row was fixed on the linen support while the fourth and fifth rows were not fixed on the linen support but fixed on each other and on the third row. The sixth row was fixed on the linen support while the seventh row was not fixed on linen support but it was fixed on the previous row and so on. According to the previous studies and investigations applied on traces of leather scale rows, it is believed that each row consisted of 50 leather scales and weighed 1.86 grams each, totally covering the chest area or the width of the chest precisely.

The rows were fixed with halfa strings on fixing points, the same had been used in the linen support. This method provided elasticity and coherence. Its' light-weight was accomplished by designing leather straps on shoulder area consisted of 32 leather scales. Each scale weighed 0.33 grams. At the same time, the shoulder decoration area consisted of 133 smaller leather scales about 29–32 mm in length.

The row in chest area weighed 90 grams, while the 9 remaining rows weighed 810 grams. Eight rows were reconstructed, while the ninth row was preserved in a box with the armour unfixed. Straps in shoulder area weighed 53.5 grams.

It can be stated that conservation helped in clearing and discovering not only the components of the cuirass in an accurate and precise way but also helped revealing manufacturing techniques.

## **Results**

After the completion of conservation of the leather scale armour of Tutankhamun, the armour reached a stable condition. Conservation materials used in this case were very successful and gave pleasing results. Besides enhancing the condition, conservation helped in clearing and discovering not only the components of the scale armour in an accurate and precise way but also helped in revealing manufacturing techniques. Different investigations and analyses assisted in revealing manufacturing techniques and materials

used in the armour. There was big challenge in defining the place of each part of the materials on the armour but the conservation and examination solved the mystery. Conservation explained the composite artifact, which contained several materials manufactured by several workers. The authors found during the conservation procedures that the linen support consisted of 12 layers in the upper part near the suspenders, 6 layers in chest area and 3 layers in abdominal area.

## Discussion

The leather scale armour of Tutankhamun is considered rare and there are no similar complete examples. According to the authors, most of deterioration to the leather scale armour was due to previous conservation materials and unsuitable storage methods, which led to severe damage to the delicate organic materials<sup>26</sup>. Infra-red imaging revealed tiny cracks and holes on the leather scales due to dryness. Researchers attributed this deterioration to bad storage condition of the sensitive organic armour for more than 100 years in addition to the previous hot treatment. The conservation procedures of the leather scale armour demonstrated a series of successful measures that created durable and sustainable condition for the leather scale armour. The researchers agree with Storch and the Canadian conservation institute on using soft brushes in mechanical cleaning. But they disagree on using vacuuming due to the fragility of the object<sup>27</sup>. Chemical cleaning applied with Isopropyl alcohol on leather provided an effective method for mold removal and was most suitable for the sensitive object as it evaporated rapidly<sup>28</sup>. Kite had right opinion on using Klucel G in consolidation but they were incorrect in suggesting using Paraloid B67 in consolidation and Gelatin. Paraloid B67 makes leather rigid, while Gelatin encourages biodeterioration<sup>29</sup>. Researchers agree with Abdel Kareem on using Crepeline in supporting damaged textiles<sup>30</sup>, but disagree with him on using Lascaux 498, which they replaced it with Beva 371 film in supporting leather scales as it's more suitable in the studied case<sup>31</sup>. The researchers agree with Berger on using Beva 371 (solution and film) to support leather and textiles<sup>32</sup>, especially applied by heat, as it is stronger in bonding than the wet treatment. The same could be said about the treatment suggested by Cser<sup>33</sup> Mailand, said that treatment was successful, especially for using Crepeline in supporting damaged textiles<sup>34</sup>. Considering the exhibition and storage conditions of the leather scale armour,

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<sup>26</sup> STORCH 1987: 3-4.

<sup>27</sup> CANADIAN CONSERVATION INSTITUTE 1992: 4.

<sup>28</sup> HASSAN 2019: 224.

<sup>29</sup> KITE & THOMSON 2006: 124.

<sup>30</sup> ABDEL KAREEM 2021: 13.

<sup>31</sup> KRONTHAL et Al. 2003: 358.

<sup>32</sup> CALNAN 1991: 49-50.

<sup>33</sup> CSER 2003: 3-5.

<sup>34</sup> KRONTHAL et Al. 2003: 360-362.

the researchers suggested preserving the object at 45% to 55% RH and 18 to 20° C to avoid further damage to the delicate object<sup>35</sup>. The researchers disagree with Carter on the number of layers of the linen support. During the conservation procedures, researchers found that the linen support consisted of 12 layers in the upper part near the suspenders, 6 in chest area and 3 in abdominal area. It was proved that this leather scale armour wasn't involved in any battle.

## **V. CONCLUSION**

The war cuirass of Tutankhamun was severely damaged and there is no similar. After finishing all conservation procedures, the armour reached a sustainable condition. It can be said that conservation helped in clearing and discovering the components of the scale armour in an accurate and precise way. Besides, the manufacturing technique of the cuirass was clearly identified and explained by the different conservation procedures. Using Crepeline in supporting damaged textiles proved successful and gave sustainable results. Additionally, using Beva 371 film in supporting leather objects, such as the leather scales in the leather armour, was convenient and is recommended for similar cases

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<sup>35</sup> BROWN 2002: 71-72.

## BIBLIOGRAPHY

- ABDEL KAREEM, O. : «Textile conservation past, present and future», *ARCS* 2, 2021, 1-15.
- BERTHOMIEU, C., et Al.:« Fourier Transform Infrared FTIR Spectroscopy», *Photosynthesis Research* 101/2-3, 2009, 157-170.
- BROWN, S., et Al.: *Guidelines for Environmental Control in Cultural Institutions*, Australia (Heritage Collection Council) 2002.
- CALNAN, C. & et Al., (eds.): Ageing of Vegetable Tanned Leather in Response to Variation in Climate Conditions, In: *Leather: Its Composition and Changes with Time*, Northampton (the Leather Conservation Center) 1991.
- CANADIAN CONSERVATION INSTITUTE, Care of Alum, vegetable and mineral tanned leather, CCI notes 8/2, Canda (Canadian Conservation Institute) 1992.
- CSER, L.: «Some Lining Techniques Using BEVA Solution and BEVA Gel: Notes from the Bench», *JACCR* 27, 2003, 3-5.
- HASSAN, R.:« The Restoration of Two Historic Leather Bindings According to a New Strategy», *Journal of the Institute of Conservation* 42/3, 2019, 210-225.
- HORIE, V.: *Materials for Conservation, Organic Consolidants, Adhesives and Coatings*, 2<sup>nd</sup> (ed.), Britain, Elsevier, 2010, 8-9.
- KITE, M. & THOMSON, R.: *Conservation of Leather and Related Materials*, 1<sup>st</sup> ed., Oxford (Routledge) 2006.
- KRONTHAL, L., et Al.: «Beva 371 and Its Use as an Adhesive for Skin and Leather Repairs: Background and a Review of Treatments», *JAI* 42/2, 2003, 341-362.
- MOHAMED et Al: «The Documentation and Conservation Study of King Tutankhamun's War Cuirass, Poster in the 43<sup>th</sup> annual meeting of the American institute for conservation», in: <https://www.culturalheritage.org/docs/default-source/annualmeeting/106-the-documentation-and-conservation-study-of-king-tutankhamen's-war-cuirass.pdf>, Accessed on 01/07/2023
- NICHOLSON, P.T., et Al., (eds.): *Ancient Egyptian Materials and Technology*, Cambridge (Cambridge University Press) 2000.
- SUBOOHI, N & ABDURAHEEM, K.:« Agents of Deterioration of Organic Museum Objects and Their Management: A Review», *IJCSRR* 4/9, 2021, 1108-1112.
- STORCH, P. S.: *Curatorial Care and the Handling of Skin Materials*, vol.1: *Tanned Objects, Conservation Notes*, 1987.
- THOMSON, R.: *The Manufacture of Leather, Conservation of Leather and Related Materials*, Oxford (Butterworth Heinemann) 2006.
- «**Tutankhamun: Anatomy of an Excavation**», in: <http://www.griffith.ox.ac.uk/discoveringtut/>, Accessed on 12/11/ 2022
- «**Ultrasonic Steam Cleaner mod. Steam Scalpel**», in: <https://www.ctseurope.com/gb/515-ultrasonic-steam-cleaner-mod-steam-scalpel>, Accessed on 12/10/2022
- «**Ultraviolet Imaging**», in: <https://midopt.com/solutions/monochrome-imaging/ultraviolet-imaging/>, Accessed on 17/11/2022
- VELDMEIJER, A., J., et Al.: «Tutankhamun Cuirass Reconsidered», *JEOL* 48/2, 2021,126-156.
- WILKS, H.: *Science for Conservators, Cleaning*, Museums and Galleries Commission, New York (Routledge) 2000.