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Conservation between scientific methodology and laboratory application: An integrated approach to past and present challenges

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Abstract
King Tutankhamun's 18th-dynasty tomb collection is expected to be displayed at the newly built Grand Egyptian Museum in Giza. The collection is one of the earliest attempts at conservation in modern terms, integrating a scientific approach to its long-term preservation and providing firsthand information about changes and developments in conservation practices from the time of its discovery in 1922 to the present day. One of the conservator's main roles is to investigate the causes of the changes that occur in objects and to find a methodology to minimize these changes for future generations. Hence, understanding an object's composite materials and past conservation treatments is necessary to develop a methodology for present-day conservation work. By examining four organic artifacts from Tutankhamun's tomb—a hassock or "footstool" (Carter No. 034) and four textile objects (Carter No. 054f, 044t, 021cc, and 044r)—in four case studies, a hypothesis was put forward that present-day conservation decisions are integrated with those from the past. Such past decisions, in combination with the condition or state and scientific approach at the

INTRODUCTION

The tomb of King Tutankhamun from the 18th dynasty, or New Kingdom (ca. 1342–1325 BC), was discovered on November 4, 1922, in the Valley of the Kings in Luxor by a British archaeologist and Egyptologist, Howard H. Carter (1874–1939). His team spent ten years removing and recording all of the objects from the tomb, a total of 5,398 items (Carter 1972, Reeves 1990). Around 15,000 documents from this extraction are now held by the Griffith Institute, Oxford University, and can be consulted online.[1]

The British chemist Alfred Lucas (1867–1945) acted as scientist-conservator for the Tutankhamun collections. Lucas's *Antiquities: Their restoration and preservation* (Lucas 1924) is a firsthand account of the aims and methods behind the conservation of the artifacts from the famous excavation, although it also deals with a wider spectrum of materials. The objects were moved to the Egyptian Museum, where they were displayed in the galleries or put into storage, many remaining untouched. In 2002, the Egyptian government laid the first stone for a new museum—the Grand Egyptian Museum (GEM) in Giza—where the entire Tutankhamun collection was expected to be moved and displayed in state-of-the-art galleries. The GEM's mission is "to preserve, document, conserve, research, and exhibit its collections, and to educate and entertain its visitors, whether adult or child."[2] It has adopted preventive conservation as its primary policy (Kamal et al. 2018), conserving the Tutankhamun artifacts in the adjacent GEM Conservation Center (GEM–CC) in continuous regard for the excavator's intentions and the Egyptian Museum's activities: to preserve them for future generations. Japan has provided Egypt with support to implement the GEM–CC, and since 2007 continuous development programs have been run for conservation professionals, this paper being the outcome of one such program of international cooperation.[3]

Conservation of the Tutankhamun collection is a responsibility of utmost importance. Faced with a historical challenge, approaches to conserving ancient Egyptian artifacts were studied through integrating scientific methodology and laboratory work to generate a specific solution. This paper is the result of a discussion among members of the Organic Materials Laboratory at GEM–CC on the need to examine past and present conservation methods—specifically how a decision impacts on an object's long-term preservation. By looking at four organic artifacts from Tutankhamun's tomb in four case studies, the hypothesis is presented that modern-day

time, affect the object's preservation and influence current conservation decision-making. The authors compared the similarities and differences between the four artifacts in the case studies and concluded that changes in conservation thinking and methodology had become part of each object's characteristics, and that conservation decisions taken in the past had been integrated into the objects. Similarly, conservators need to be aware that present-day conservation decisions involving advanced scientific methods and laboratory applications also affect objects and must proceed with caution, i.e., remember that less is more and that challenging situations are also an integral part of conservation.

Figure 1. Hassock (cloth, bran, and beadwork; Carter No. 034, Sr. No. 4441, GEM No. 15971). Photo: Eslam Shaheen, GEM–CC

Figure 2. Hassock after conservation. Photo: NagmEldeen Hamza, GEM–CC

conservation decisions are integrated with past decisions and, furthermore, that the present condition or state of an object affects current conservation decision-making.

CONSERVATION RECORDS AT THE TIME OF EXCAVATION

Carter and his team developed an impressive system for documenting the condition and treatment applied to individual artifacts that used cross-referenced index cards. The artifacts were exposed to two conservation interventions. The first was applied in situ—to protect them from handling while being removed from the tomb—and the second took place at a conservation laboratory set up by Lucas at the nearby tomb of Seti II (Carter and Mace 2004). The treatment involved two stages: cleaning and consolidation. Cleaning was performed using soft bristle brushes and bellows, followed by consolidation to coat the artifacts with paraffin, beeswax, or some kind of synthetic adhesive such as cellulose nitrate (celluloid) dissolved in acetone, Duroprene dissolved in xylol, or Canada balsam dissolved in xylene (Gilberg 1997). As the use of synthetic polymers was new in the 1920s, it can be said that Carter and Lucas endeavored to preserve the treasures by using advanced scientific methods for the time. Even so, when the object was "too far gone for measurement," it was "not kept."[4] It is important to note that the idea of keeping deteriorated objects in the hope that conservation techniques might be developed in the future was not envisaged. What if a suitable preservation or restoration technique is developed a hundred years from now? This is reminiscent of our current position. Case studies on the conservation of the Tutankhamun artifacts are among the earliest records of integrating today's scientific methodologies, and yet these will not be the last in the relics' lives.

OBJECT CASE STUDIES

Four case studies are discussed. The object identification numbers for the Tutankhamun collection show how the objects have changed hands and these are the key to cross-referencing the records.

Case study 1: Hassock, cloth filled with bran and decorated with beadwork (Carter No. 034, Sr. 4441, GEM No. 15971)

Carter's object cards are firsthand records that identify an object (location, size, and description) and its conservation treatment. In this case (Card No. 34-1), boiling wax was poured over the beaded object as a conservation treatment. Carter took extra notes on the materials and construction of the hassock (Card No. 34-2) in which he reconfigures the sequence of the beading techniques. On its arrival at the Egyptian Museum in 1933, the hassock was stored in a wooden box inside storage room no. 55 until it was moved to GEM–CC in 2014. Inside this box were two other cardboard boxes, one containing detached beads and the other a carbonized textile with gold leaf (Figure 1).

Upon examining the hassock at the Organic Laboratory, a large number of detached beads were observed. Much of the bran stuffing had fallen out, and the condition appeared to have worsened. Although the wax was not functioning as a consolidator, the conservator decided not to remove

Figure 3. Tapestry woven garment as stored at the Egyptian Museum (Carter No. 054f, Sr. No. 3934, GEM No. 16017). Photo: GEM–CC

Figure 4. Separating the layers of the textiles during conservation at the Organic Lab, GEM–CC. Photo: NagmEldeen Hamza, GEM–CC

it; in some places, the wax was holding the beads together even after the threads had deteriorated and any mechanical action would have destroyed the object. A conservation decision was taken to support the deformation and reconstruct some parts of the bead decoration. This was possible due to Carter's notes being informative enough to understand the beading technique and their arrangement (Carter No. 34-2), and that the object was intended for display at the GEM. In summary, the conservation involved reshaping and re-constructing the object into a "footstool" by re-threading the bead decoration (Figure 2).

Case study 2: Tapestry woven garment (Carter No. 054f, Sr. No. 3934, GEM No. 16017)

Carter's record for this object indicates that the garment was entirely bunched together and sprayed with a solution of cellulose nitrate (recorded as celluloid by Carter) in acetone. From its arrival at the Egyptian Museum in 1933, the garment was kept inside storage room no. 55 until 2015, when it was moved to GEM–CC (Figure 3).

The synthetic polymers held the fragmented pieces together and it was difficult to separate them, as they had consolidated into a mass. Our first decision was not to risk opening the fabric. However, after carefully experimenting with humidification using acetone and water vapors with an ultrasonic humidifier (Tímár-Balázsy and Eastop 1998b), the cellulose nitrate was found to soften and the fragments could be successfully separated (Selwitz 1988). This treatment led to a surprising discovery on the inscriptions woven into the garment that opened up a new interpretation of King Tutankhamun's familial relationships, in that the cartouche did not belong to him but perhaps to another king or even a queen, providing new evidence concerning his parents (Tawfik et al. 2018). This demonstrated that records of past treatments can help construct a conservation methodology. Although the cellulose nitrate could not be removed from the object, it played a certain role in its preservation. Our current approach used this past treatment and devised a laboratory practice using modern tools and scientific principles in which the cellulose nitrate could be reactivated by acetone. Hence, this case study showed that past conservation activity is integrated into the present approach, and through experimentation challenges can open new doors to better understand our heritage (Figure 4).

Case study 3: Ornamental garment (Carter No. 044t, Sr. No. 4357, GEM No. 14695)

The excavation notes indicated that the ornamental garment, made from linen, had many metal sequences and was in very bad condition. Carter decided to spray it with a "strong solution of cellulose acetate in acetone."[5] Next, the garment was placed on a glass sheet covered with fabric, packed in a wooden box, and transferred to the EM in Cairo in 1933, where it was stored (Figure 5). In 2014, the garment was moved to the GEM–CC.

The garment was in extremely poor condition: the fabric and embroidery thread, which appeared to be linen, had turned completely dark brown, revealing an accelerated state of cellulose hydrolysis and carbonization. The metal sequins on the surface were in good condition, indicating a

Figure 5. Ornamental garment, before re-mounting (Carter No. 044t, Sr. No. 4357, GEM No. 14695). Photo: Eslam Shaheen, GEM–CC

Figure 6. The garment after mounting in 2019 by the staff of the Organic Lab, GEM–CC (Carter No. 044t, Sr. No. 4357, GEM No. 14695; the small piece: Sr. No. 3920, GEM No. 14061). Photo: Mohamed Ragab, GEM–CC

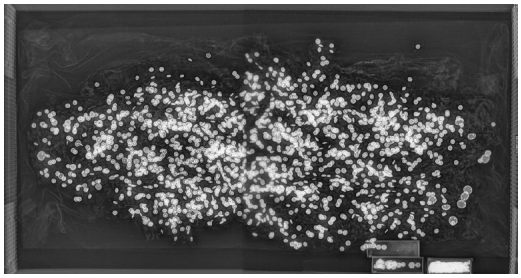

Figure 7. X-ray photograph of Carter No. 044t, Sr. No. 4357, GEM No. 14695. Photo: Hidetomo Mastushima, GEM–CC/GEM–JC

high content of gold. The object was under contract with the GEM–JC Project (see Note 3), and after discussion with the Japanese team, the decision was made not to treat it. It was placed in a concave mount made of archival material constructed by the members of the organic lab (Figure 6). It was then placed in a UV-cut, low reflectance, and antistatic case that was intended to minimize human and environmental hazards. X-ray photography revealed many underlying metal sequences that surface examination alone could not detect (Figure 7). This technology was not available to Carter nor was it present at the Egyptian Museum.

The case study demonstrated that scientific technology is becoming increasingly integrated into laboratory application. Advancements in new technology will reveal more opportunities to learn about the object—if preserved in a stable environment.

Case study 4: Decorated garments (Carter No. 021cc, Sr. No. 3274, GEM No. 15924 and Carter No. 044r, Sr. No. 3264, GEM No. 14060)

This case study consisted of two garments. Carter No. 021cc is a head covering representing a protective bird, made with colored linen thread in a tapestry technique. After excavation, it was "sprayed with a celluloid in amyl acetate" solution.[6] Carter No. 044r is an appliquéd garment with alternating blue, red, and green fabric strips. It was sprayed with cellulose acetate in amyl acetate (Figure 8). Since arriving at the Egyptian Museum in 1933, the garments have been kept in storage room no. 55.

The artifacts underwent a further intervention as part of a doctoral study on the conservation and restoration of antiquities at Cairo University (Abla 2001). Abla conducted experiments on mock samples and subsequently treated the two artifacts. One of the aims of the study was to investigate conservation methods for ancient Egyptian archaeological textiles, which involved experimental study and the development of a conservation methodology (Abdel-Kareem 2001).

Fifteen years after their second intervention, the two objects arrived at GEM–CC (Figure 9). The treatment carried out in 2001 had changed the artifacts dramatically and was non-reversible (Tétreault 1999). An active decision was taken not to perform any further treatment and to leave the object as it was (Ashley-Smith 2018). However, plans exist to produce a digital reconstruction of the object to help with its fuller interpretation.

Table 1. Case studies

Object type	Object registration number	Object material	Previous intervention
Hassock: cloth, bran, and beadwork	Carter No. 034	Beads, plant remains, textiles, leather	Boiling wax
Textile (tunic): tapestry woven garment in colors	Carter No. 054f	Linen, dyes	Sprayed with solution of celluloid in acetone
Textile: ornamental garment	Carter No. 044t	Linen, gold	Sprayed with strong solution of cellulose acetate in acetone
Textile: Tapestry woven garment	Carter No. 021cc	Linen, gold	Gold tarnished. Sprayed with strong solution of celluloid in amyl acetate
Textile: decorated garment	Carter No. 044r	Linen, gold	Sprayed with celluloid in amyl acetate

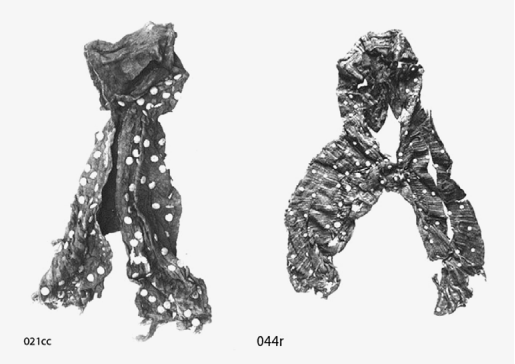

Figure 8. Decorated garments (Carter No. 021cc, Sr. No. 3247; GEM No. 15924; and Carter No. 044r, Sr. No. 3264, GEM No. 14060). Photo: Harry Burton. Courtesy of The Griffith Institute

Figure 9. Decorated garments, treated in 2001 (Carter No. 021cc, Sr. No. 3274, GEM No. 15924 and Carter No. 044r, Sr. No. 3264, GEM No. 14060). Conserved in 2001 (Abla 2001). Photo: GEM–CC

DISCUSSION

In the four case studies described, all of the objects shared the fact that they were found in the "antechamber" of Tomb 62 in the Valley of the Kings. They were all similar in that they were made of organic matter, mainly linen, and in very poor condition, showing a serious degree of cellulose degradation, darkening, and embrittlement of the fibers (Tímár-Balázsy and Eastop 1998a). The aim was to preserve the objects by means of a scientific conservation treatment at the time of excavation. This was conducted by Carter and Lucas and documented in the written notes, drawings, and photographs by Harry Barton. They were moved for storage to the Egyptian Museum around 1933 and then to the GEM–CC around 2014. The four objects, with seemingly similar conditions, showed differences in how they were recorded, treated, stored, and re-treated before coming to the GEM–CC. Our observation and decision about their conservation also varied, from reconstructive treatment to remounting, despite the institutional mandate to choose primarily preventive conservation. What were the reasons behind these decisions?

In the first case study on the hassock (Carter No. 034), the conservation decision depended on the availability of past written records, drawings, and photographs of the object. As the secondary material was informative, the conservation took a more restorative direction aimed at the object's display at the GEM.

In the second case study on the tapestry woven garment (Carter No. 054f), at the time of excavation, it was sprayed with cellulose nitrate, which did not keep the fibers together as intended, hence the aim of the treatment had been unsuccessful. It was decided not to take any further action but to place the object in a new mount and cover instead. The object was examined with X-ray photography, which revealed metal decorations that could not be discovered by surface examination alone. This case study supported the idea of keeping options open for future developments in conservation.

In the third case study on the ornamental garment (Carter No. 044t), there was very little information recorded by Carter. The conservation approach was decided after considering the chemical information on past conservation treatments and laboratory experiments. The conservator's training and the availability of equipment influenced the decision to challenge the status quo and unfold the pieces. This led to new archaeological insights and interpretation of the garment, and exemplified the need to adopt a proactive approach.

In the fourth case study on the decorated garments (Carter No. 021cc and 044r), the objects in question were educational in purpose, and the experimental nature of the study would have changed their characteristics to a great extent. Recognizing this, it was decided not to undertake any conservation treatment.

This collective study taught us that an integrated approach exploring past records, publications, and scientific and practical conservation methodology is fundamental in deciding how to proceed in a present-day context, and

that there is no single formula that applies to all conservation. It is possible that future developments may change every aspect of conservation, and that our treatment may not necessarily be the last. Thinking about future effects when planning conservation is necessary because, as these case studies demonstrate, developments will be integrated into an object and become part of its characteristics. In other words, what has been done and what is being done now can have multiple impacts on the future preservation of our heritage.

CONCLUSION

The preservation of Tutankhamun's tomb collection is a huge challenge. Working in direct contact with the objects and studying the debates and practices of the past while reviewing our own practices revealed that present-day conservation decisions integrate decisions from the past more comprehensively than initially realized. It was discovered that past decisions, in combination with the condition or state of an object and past trends in scientific approach, affect an object's characteristics, even becoming part of it. It is necessary to be aware that our present-day conservation decisions will affect the object in the same way and to keep in mind that scientific methodologies and laboratory applications are both advancing. Conservators must take care not to be heavy-handed and to remind themselves that less is more—that the challenge to discover the best conservation approach is integral to their efforts.

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NOTES

1 For more information, see "Tutankhamun: Anatomy of an Excavation": http://www.griffith.ox.ac.uk/discoveringTut/ (accessed 5 May 2020).

2 The Grand Egyptian Museum: http://gem.gov.eg/index/AboutGEM%20-Vision&Mission.htm (accessed 5 May 2020).

3 The Grand Egyptian Museum Joint Conservation Project (GEM–JC Project), a joint conservation project between the Japan International Cooperation Agency (JICA) and the GEM. For more information, see https://www.jicagem.com/ (accessed 5 May 2020).

4 Carter No. 050k: "(k) Remains of the shirt or shawl, too far gone for measurement: not kept." http://www.griffith.ox.ac.uk/gri/carter/050k.html (accessed 5 May 2020).

5 Carter No. 044t: "Sprayed with strong solution of cellulose acetate in acetone." http://www.griffith.ox.ac.uk/gri/carter/044t.html (accessed 5 May 2020).

6 Carter No. 044r: "Treatment sprayed with celluloid in amyl acetate." http://www.griffith.ox.ac.uk/gri/carter/044r-c044r-3.html (accessed 5 May 2020).

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