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THE IMPORTANCE OF TOMOGRAPHY STUDYING WOODEN ARTEFACTS: A COMPARISON WITH RADIOGRAPHY IN THE CASE OF A COFFIN LID FROM ANCIENT EGYPT

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Abstract

X-ray radiography is nowadays widely employed in the Cultural Heritage field and can give many and useful information on different topics related to artworks and archaeological finds. On the other hand, tomography is less diffused and more time-consuming and expensive, but overcomes the main limitation of radiography, that is the projection of the entire volume on a plane, losing information about the third dimension. This is especially true when radiography is applied to objects with complex geometry or different materials: in these cases, the real distribution of pieces and materials is sometimes impossible to understand and a tomography is necessary. In this paper, we will show the case study of the Taiefmutmut's coffin lid, a woman from Ancient Egypt, analysed with both radiography and tomography. This case is particularly significant because, even if the object is relatively simple both for geometry and materials, the results obtained with the two techniques are noticeably different. In particular, the tomography gives a larger amount of information, both on the building technique, on the state of conservation and on previous restorations.

Keywords: *Digital radiography; X-ray tomography; Coffin; Ancient Egypt; Restoration; Preservation; Cultural heritage.*

Introduction

X-ray imaging techniques are widely employed in the cultural heritage field. Among them, digital radiography (DR) is the most used and gives exhaustive results, especially for objects that are flat (e.g. paintings on canvas) or where the third dimension is not so extended (e.g. paintings on panels). For three-dimensional objects, radiography can give useful information, but only with computed tomography (CT) one can fully understand the position of different parts or the different distribution of materials inside the object.

In this paper, the comparison between radiography and tomography of the same "relatively flat" object is presented: it is the lid of an ancient Egyptian coffin, whose wood thickness is relatively thin (around 4.5cm). It will be shown that also for this kind of objects that

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in principle can be analysed with a simple radiograph, tomography allows to obtain many information invisible with radiography.

In the last years CT has been successfully applied in the Cultural Heritage field, to answer different types of questions, both of artistic [1, 2], archaeological [3-5] and anthropological interest [6-8]. Thanks to these applications, some instruments dedicated to the analysis of Cultural Heritage materials have been specifically designed and developed [9-12]: due to the high variability of the cultural heritage objects to be analysed, both in sizes and materials, these systems have a high versatility in their performance, both in terms of resolution and time acquisition, even though a single instrument can not be able to analyse all the different combination of materials and dimensions. Moreover, despite the limitation of information that can be obtained, in some cases the digital radiography remains the only possibility for structural investigation, usually for safety reasons in case of degraded conservation condition of the finds, or due to the limited availability of time and geometries, if the object can not be moved from its position or outside the museum.

Regarding the ancient Egypt finds, CT has mainly been applied to mummies using medical scanners, obtaining interesting information on habits, diseases, life and death of ancient Egyptians [13, 14]. During the CT scans only in few cases the coffin has also been analysed [15-18], but just as the container of the mummy, that usually is the real focus of the studies. The only published CT of coffins we know of, that have been expressly analysed to be studied, have recently been presented at the exhibition “Death on the Nile” at the Fitzwilliam Museum [19].

Different analytical methods have already been applied to the study of Egyptian coffins, usually with a multi-techniques approach [20-23], and in some cases X-ray radiography have also been employed [24, 25]. Even if this technique can give much useful information, some clues can be highlighted only by means of a three-dimensional analysis of the find. For this reason, we decided to analyse the coffin lid by means of tomography, to investigate a possible reuse of the employed materials, to better understand the building technique and to evaluate its state of conservation and previous restorations.

This analysis has been carried out in a wider project of restoration of a series of coffins performed at the “Centro Conservazione e Restauro La Venaria Reale” for the re-opening of the “Museo Egizio” of Turin in 2015.

Experimental

The analysed lid (Fig. 1) is part of the set of coffins of the lady Taiefmutmut (Inv. Nr. Cat. 2228, CGT 10119-10120), chantress of Amun, which was acquired by the Museo Egizio of Turin with the Drovetti Collection [26]. Their provenance is not recorded. According to textual and stylistic criteria they date from the 21^{th} dynasty (1076-746 BC) and were probably discovered in the Theban necropolis [27]. They belongs to a particular group called “yellow coffins”, characterised by the yellow colour of the background, and fully covered with vignettes and texts from various funerary books. The set of Taiefmutmut’s coffins includes an anthropoid, bivalve wooden coffin and an anthropoid mummy board. The lid is inspired by models of the New Kingdom and its dimensions are $31 \times 50 \times 182cm^3$, with a medium wooden thickness of about 4.5cm. It represents the deceased as a living person, with the left arm flexed over the breast, the right arm at side, wearing a long dress, from which the feet are sticking out (Lid of type IVc according to [28]). This coffin lid has been carved and assembled to obtain the anthropoid form and has been painted and enriched with relief decorations. Examining the verse, the body appears assembled from at least three longitudinal planks forming the central portion, and other smaller blocks to form the perimeter of the anthropomorphic silhouette and the profile functional to the assembled with the box. It is adorned and polychrome only on the outside, with female attributes, such as the black wig that falls on the decorated breast and the earrings at the sides of the face.

Fig. 1. The analysed coffin lid (Cat. 2228/1): frontal, back and side views.

The CT scanner employed for this analysis has been designed, developed and installed in a shielded area at the "Centro Conservazione e Restauro La Venaria Reale" in the framework of the neu_ART regional project [10, 11]. It has been realised to perform radiography and tomography of large artworks, overcoming the main limit of medical CT scanner applied to the field of Cultural Heritage, which is the gantry diameter, limiting the dimensions of analysable objects. Moreover, thanks to the fact that this instrument is installed in a centre of restoration, the artworks or finds already there to be restored do not have to be moved to a hospital for analysis; this fact avoids other travels of delicate objects, for which every movement is very difficult and sometimes dangerous. This instrument already showed its potentiality in the analysis of a large piece of furniture [2] and a soil-block from an archaeological excavation [5]. The main parts of the scanner are an X-ray source and a linear detector: both can move vertically to select the height of the object to be analysed. Moreover, the source can be distanced or approached to the detector, to optimise the acquisition geometry, while the detector can move horizontally to acquire a single radiograph large up to 3.5m. To perform a tomography the analysed object is placed on a rotary stage and many radiographs are acquired, at different angles.

In order to conduct the CT of the coffin lid in a safe and easy way, it was necessary to build a special supporting structure, which should be robust and have a low radiopacity. It was realised in wood and equipped with a system of adjustable straps, which allowed maintaining the coffin lid in a vertical position, anchoring it, and avoiding unloading the weight on the lower portion.

Six set of scans, each one at a different height, were necessary to acquire the whole object. All the experimental details of this measurement are reported in Table 1.

Table 1. Details of the experimental setup; SOD and ODD are measured from the rotational centre of the object

Dimensions of the coffin lid	31 × 50 × 182cm^3
Source-Detector Distance (SDD)	3.69m
Source-Object Distance (SOD)	3.18m
Object-Detector Distance (ODD)	0.51m
Magnification	1.16X
Detector output	12bit
Detector pixel size	200µm
Binning	2 × 2
Image pixel size	400µm
Reconstructed voxel size	340µm
Tube voltage	180kV
Tube current	5mA
Focal spot size (EN 12543)	3mm
Detector scan speed	2.2m/min
Horizontal portions	6
Number of projections/portion	1080
Angular step	0.25°
Scanned area for each portion	90 × 51.2cm^2
Image dimensions for each portion	4500 × 2560 pixel
Average acquisition time for each portion	15 hours
Total time	90 hours

The CT scan parameters have been decided taking into account the dimensions and the materials of the coffin lid. To reduce the penumbra effect, the rotational centre has been set as closest as possible to the detector, according to the overall dimensions of the lid and the supporting structure. After preliminary radiographs the tube voltage has been set at 180kV to obtain a good X-ray signal in the most thick and radiopaque portion, the feet of the coffin lid. Using the highest tube current available at the selected voltage and optimising the binning, the scan speed has been selected to maximise the detector signal, avoiding saturation. In these optimised operating conditions, the total acquisition time was evaluated to be 90 hours. The long measurement time has been possible because in this case the duration was not a limiting factor, thanks to the non-critical conservation condition of the find and because during the CT scan temperature and humidity are controlled. It is worth noticing that in other cases, when the degradation of the object is high or it cannot stay in the vertical position for long time, the acquisition parameters can be decided differently to reduce the measurement duration, necessarily losing, however, image contrast or spatial resolution (always below one millimetre).

In the usual methodological approach, also adopted for this case, the CT scan has to be performed after a preliminary radiographic investigation of the whole object. In case of limited time one can focus only on specific areas, to address unsolved issues highlighted in digital X-ray images but understandable only through the evaluation of the third dimension. Even if this method can optimise the obtainable information in case of limited time, a CT dataset of the entire object, besides clarifying points coming out from radiography, can suggest and solve new issues, invisible in radiographs.

The radiograph shown in figure 2 has been obtained stitching six radiographs, acquired at different heights of the coffin, by means of the ImageAssembler software by PanaVue. The CT sections have been reconstructed using a filtered back-projection algorithm, with fan-beam geometry approximation, by means of a non-commercial software-utility developed by Dan

Schneberk of the Lawrence Livermore National Laboratory (USA). The 3D rendering and segmentation shown in figure 2 has been realised using VGStudio MAX 2.2 from Volume Graphics.

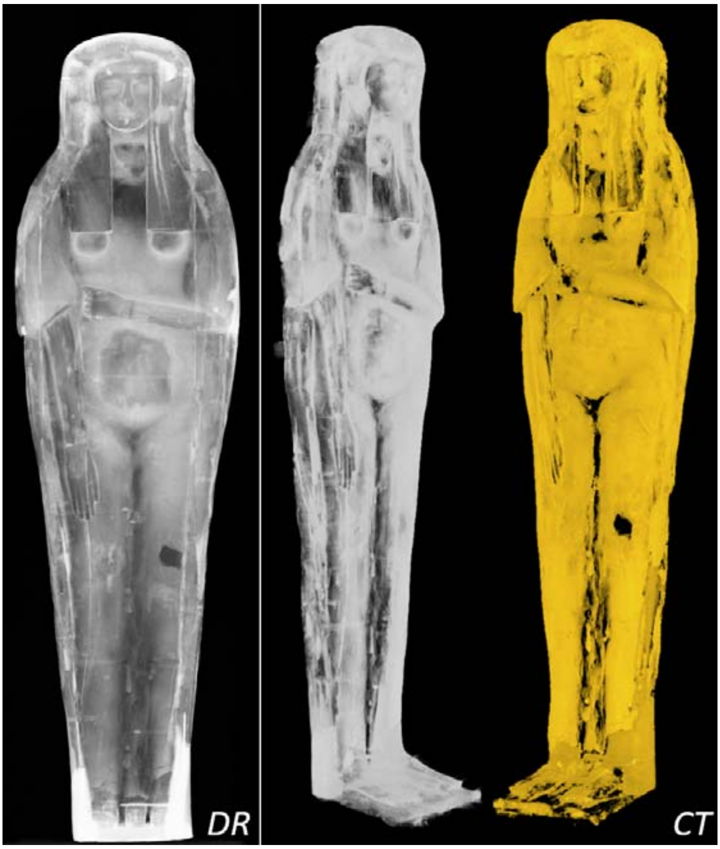

Fig. 2. Frontal X-ray radiograph of the analysed coffin lid (on the left) and 3D rendering of the CT reconstruction of the entire volume (in the middle) and segmentation of the preparation layer (in yellow on the right).

Results and Discussion

X-ray imaging (both radiography and tomography) allowed us to obtain much information about the building technique, the state of conservation and previous restorations of the coffin. In the following, the main results about these topics will be shown, comparing radiographic and tomographic results and highlighting the high number of details visible only by means of tomography.

Building technique

A scheme of the various parts assembled to create the coffin lid has been obtained from direct observation of the find and using both radiograph and CT reconstructions. The radiograph highlights that the coffin lid is made with three main longitudinal wooden planks, forming the flat part of the lid. Other smaller wooden blocks form the lateral parts, the sides of the lid and some anatomical parts, like arms, face, feet, etc. These last parts are fixed to the main flat part through wooden-dowels; some of them can be seen in the radiograph, but only in tomographic section the full length and direction can be appreciated, as seen clearly for example in the face of the coffin (Fig. 3, yellow arrows). In particular, the observation of CT data from different perspectives, horizontal, vertical and lateral sections, allowed distinguishing the dowels from a filler material, which on radiograph were similar (Fig. 3, orange arrow). Two larger blocks, one curved and one flat, close the coffin on the head side and on the feet side respectively. The wig and the breast are obtained from the basic plank as we note the continuity of the wood fibre and the cracking through all three elements (Fig. 4, green arrows).

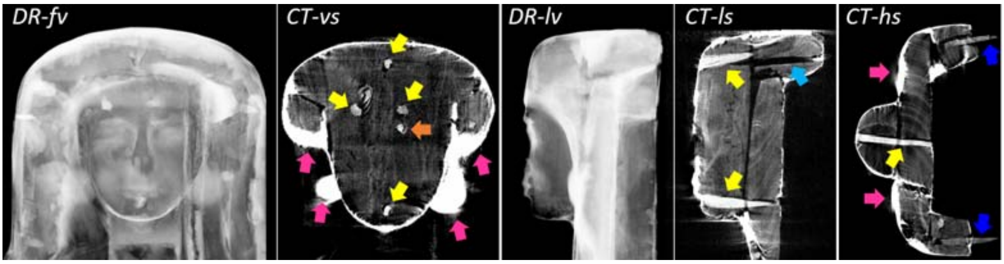

Fig. 3. Details of the head of the coffin lid: a comparison between digital radiography (DR, both frontal view -fv- and lateral view -lv-) and significant sections from the computed tomography volume (CT, both horizontal -hs-, vertical -vs, and lateral -ls- sections) are shown. Coloured arrows indicate: wooden dowels (yellow); thick preparatory material layer (pink); filler material (orange); tenons and mortises (blue); an empty cylindrical hole (light blue).

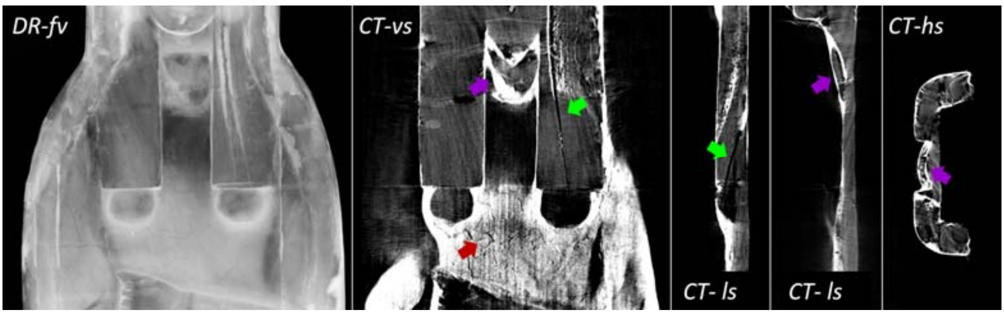

Fig. 4. Details of the upper part of the chest of the coffin lid: digital radiography (DR) and computed tomography (CT) vertical (vs), lateral (ls) and horizontal (hs) sections are shown. Coloured arrows indicate: crack in the wood (green); possible re-use (purple); cracks in the preparatory layer (dark red).

Along the perimeter, on the lower part of the lid, there are seven mortises, functional to join the lid with the coffin box, through seven tenons, four of which are still present today (Fig. 3 and 5, blue arrows). These tenons are blocked thanks to circular dowels transversely inserted through holes made in the lateral part of the lid.

A filling material is present where there are jutting parts in the coffin (wig, breasts, arms and feet); it can easily be detected in the radiograph, because of its higher radiopacity, but only in CT the extent and the thickness of the preparatory layer can be evaluated, as can be clearly seen for example in the head (Fig. 3, pink arrows). In particular, thanks to the CT, we noticed that the right sleeve thickness was obtained from the basic plank, refined with a huge quantity of preparatory material (Fig. 5, pink arrow). In correspondence with the fold of the mantle over the right arm was also observed the addition of a small wooden block assembled by a dowel; the observation of the sequence of horizontal sections has allowed the identification of the intersection of this dowel with another, functional to the assembly of the sides with the front (Fig. 5, yellow arrows).

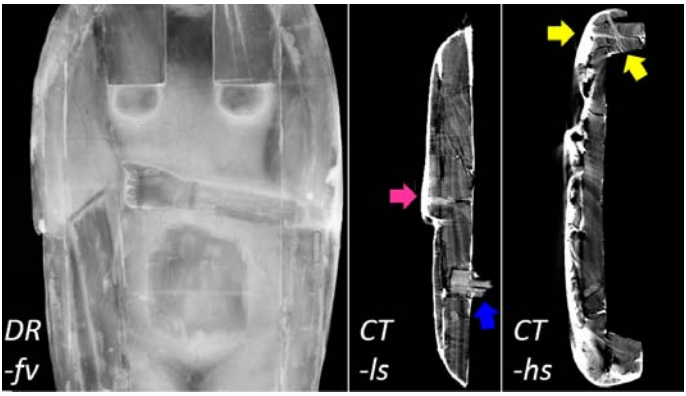

Fig. 5. Details of the arms and abdomen of the coffin lid: digital radiography (DR) and computed tomography (CT) lateral (ls) and horizontal (hs) sections are shown. Coloured arrows indicate: tenon and mortise (blue); thick preparatory material layer (pink); wooden dowels (yellow).

The detected presence of a highly radiopaque layer, of a similar response to that preparatory, even below of assembled wood portions, allowed to hypothesize the possible reuse of the lid, with a substantial change of the volumes; this characteristic has been identified thanks to the observation of the lateral sections and horizontal ones (Fig. 4, purple arrows) acquired by CT scan in correspondence of the portion below the chin. Another feature, that allow hypothesizing a re-use of some materials, is the presence of empty cylindrical holes (Fig. 1 and 6, light blue arrows), probably realised to hold a dowel in the previous use of the wooden block. As it has been confirmed by recent studies [29] the practice of coffin reuse was quite common in the Third Intermediate Period. In fact, a large number of items were made by partly covering with plaster and repainting older coffins from the New Kingdom, in order to update the decoration.

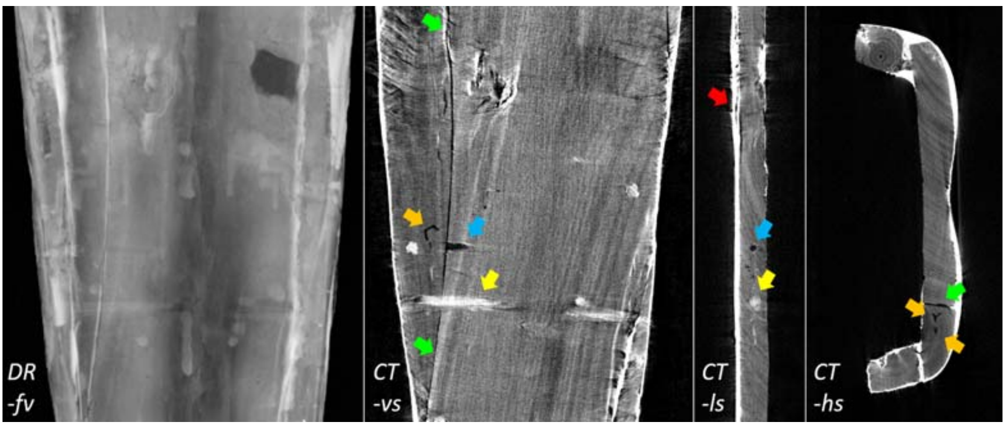

Fig. 6. Details of the legs of the coffin lid: digital radiography (DR) and significant sections from the computed tomography volume (CT, both horizontal -hs-, vertical -vs-, and lateral -ls- sections) are shown. Coloured arrows indicate: space between longitudinal wooden planks (green); a wooden cylindrical pin (yellow); an empty cylindrical hole (light blue); a lack of adhesion (red); xylophagous insects holes (dark yellow).

Previous restorations

The lower part of the coffin lid underwent a strong restoration in the past, as can be already seen with the naked eye (Fig. 1): the missing parts of ankles and heels were filled with a material of a dark-ochre colour. From the radiograph (Fig. 7, dark green arrows) the material appears more radiopaque than the wood, so it is clearly distinguishable and the extension of this restoration can be evaluated. Moreover some modern screws have been inserted to realise and strengthen the conservative grouting, as can be already seen from the radiograph. Actually, due to the projection of the volume on a plane, the information in the radiograph is not exhaustive and only the CT sections and 3D rendering allow the complete understanding of the real distribution of the screws, their position and orientation (Fig. 7, brown arrows).

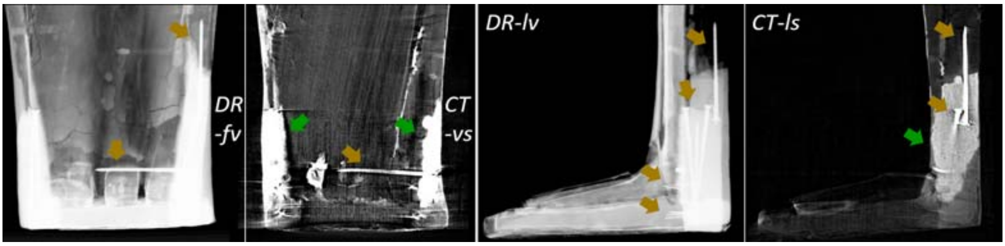

Fig. 7. Details of the feet of the coffin lid: a comparison between digital radiography (DR, both frontal view -fv- and lateral view -lv-) and significant sections from the computed tomography volume (CT, both vertical -vs-, and lateral -ls- sections) are shown. Coloured arrows indicate: material from previous restoration (dark green); modern screws (brown).

State of conservation

CT reconstruction allowed us also to evaluate the presence and the extension of some degradation phenomena: cracking of the wood, lack of adhesion of the preparation layers and the holes created by xylophagous insects.

The wooden support appeared lacking in some modelling details, such as the knees and all the edges of the box, subject to losses of minor and medium entities. Cracks of the wooden support have been also detected: in particular there was a slit parallel to the basic plank, under wig and left breast (Fig. 4, green arrows).

The pictorial layer appeared adherent to the preparation, but there were adhesion defects of the preparatory layers from the wooden support; in particular, an adhesion defect of the filler used in a previous intervention, from the wooden support (Fig 6, red arrow), has been noticed. Losses of medium of big entity have been also detected (left leg), such as abrasions in correspondence of the right leg, both already visible at naked eye.

Another feature clearly visible only by CT sections is the distribution and directions of the internal cracks of the preparatory layer (Fig. 4, dark red arrow). Moreover the extension of the xylophagous insects attack can be evaluated: despite the age of the artefact, it is not largely diffused, but is relatively concentrated in few areas (Fig. 6, dark yellow arrows).

Conclusions

The analyses performed on the Taiefmutmut's coffin lid demonstrated that computed tomography can give much valuable information about its building technique, its state of conservation and previous restorations, in an absolutely non-invasive way. Most of the evidences that came out could not be obtained nor from a single radiograph, neither from many radiographs taken ad different angles.

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References

[1] M.P. Morigi, F. Casali, M. Bettuzzi, D. Bianconi, R. Brancaccio, S. Cornacchia, A. Pasini, A. Rossi, A. Aldrovandi, D. Cauzzi, *CT investigation of two paintings on wood tables by Gentile da Fabriano*, **Nuclear Instruments and Methods in Physics Research A, 580**(1), 2007, pp. 735-738.

[2] A. Re, F. Albertin, C. Avataneo, R. Brancaccio, J. Corsi, G. Cotto, S. De Blasi, G. Dughera, E. Durisi, W. Ferrarese, A. Giovagnoli, N. Grassi, A. Lo Giudice, P. Mereu, G. Mila, M. Nervo, N. Pastrone, F. Prino, L. Ramello, M. Ravera, C. Ricci, A. Romero, R. Sacchi, A. Staiano, L. Visca, L. Zamprotta, *X-ray tomography of large wooden artworks: the case study of "Doppio corpo" by Pietro Piffetti*, **Heritage Science, 2**(19), 2014, pp. 1-9.

[3] M. Rossi, F. Casali, P. Chirco, M.P. Morigi, E. Nava, E. Querzola, M. Zanarini, *X-ray 3D computed tomography of bronze archaeological samples*, **IEEE Transactions on Nuclear Science, 46**(4), 1999, pp. 897-903.

[4] M. Bettuzzi, F. Casali, M. P. Morigi, R. Brancaccio, D. Carson, G. Chiari, J. Maish, *Computed tomography of a medium size Roman bronze statue of Cupid*, **Applied Physics A, 118**, 2015, pp. 1161-1169.

[5] A. Re, J. Corsi, M. Demmelbauer, M. Martini, G. Mila, C. Ricci, *X-ray tomography of a soil block: a useful tool for the restoration of archaeological finds*, **Heritage Science, 3**(4), 2015, pp. 1-7.

[6] M.C. Martina, F. Cesarani, R. Boano, E. Rabino Massa, C.C. Venturi, G. Gandini, *Multidetector CT of an Antillean Zemi Idol*, **RadioGraphics, 30**, 2010, pp. 1993-1999.

[7] F. Bernardini, C. Tuniz, A. Coppa, L. Mancini, D. Dreossi, D. Eichert, G. Turco, M. Biasotto, F. Terrasi, N. De Cesare, Q. Hua, V. Levchenko, *Beeswax as Dental Filling on a Neolithic Human Tooth*, **PLoS ONE, 7**(9), 2012, e44904.

[8] C. Tuniz, F. Bernardini, I. Turk, L. Dimkaroski, L. Mancini, D. Dreossi, *Did Neanderthals Play Music? X-Ray Computed Micro-Tomography of the Divje Babe 'Flute'*, **Archaeometry, 54(**3), 2012, pp. 581-590.

[9] M.P. Morigi, F. Casali, M. Bettuzzi, R. Brancaccio, V. D'Errico, *Application of X-ray Computed Tomography to Cultural Heritage diagnostics*, **Applied Physics A, 100**, 2010, pp. 653-661.

[10] M. Nervo, **Il Progetto neu_ART. Studi e applicazioni/Neutron and X-ray Tomography and Imaging for Cultural Heritage, Cronache, 4**, Editris, Torino, 2013.

[11] A. Re, F. Albertin, C. Bortolin, R. Brancaccio, P. Buscaglia, J. Corsi, G. Cotto, G. Dughera, E. Durisi, W. Ferrarese, M. Gambaccini, A. Giovagnoli, N. Grassi, A. Lo Giudice, P Mereu, G. Mila, M. Nervo, N. Pastrone, F. Petrucci, F. Prino, L. Ramello, M. Ravera, C. Ricci, A. Romero, R. Sacchi, A. Staiano, L. Visca, L. Zamprotta, *Results of the Italian neu_ART project*, **IOP Conference Series: Materials Science and Engineering 37**, 2012, 012007.

[12] C. Tuniz, F. Bernardini, A. Cicuttin, M.L. Crespo, D. Dreossi, A. Gianoncelli, L. Mancini, A. Mendoza Cuevas, N. Sodini, G. Tromba, F. Zanini, C. Zanolli, *The ICTP-Elettra X-ray laboratory for cultural heritage and archaeology*, **Nuclear Instruments and Methods in Physics Research A, 711**, 2013, pp. 106-110.

[13] F. Cesarani, M. C. Martina, R. Boano, R. Grilletto, E. D'Amicone, C. Venturi, G. Gandini, *Multidetector CT Study of Gallbladder Stones in a Wrapped Egyptian Mummy,* **RadioGraphics, 29**, 2009, pp. 1191-1194.
[14] B. Brier, P. Vinh, M. Schuster, H. Mayforth, E.J. Chapin, *A Radiologic Study of an Ancient Egyptian Mummy with a Prosthetic Toe*, **The Anatomical Record, 298**, 2015, pp. 1047-1058.
[15] S. Hughes, R. Wright, M. Barry, *Virtual reconstruction and morphological analysis of the cranium of an ancient Egyptian mummy*, **Australasian Physical and Engineering Sciences in Medicine 28**(2), 2005, pp. 122-127.
[16] S.S. Chan, J.P. Elias, M.E. Hysell, M.J. Hallowell, *CT of a Ptolemaic Period Mummy from the Ancient Egyptian City of Akhmim*, **RadioGraphics, 28**, 2008, pp. 2023-2032.
[17] E. Teeter, M. Vannier, *Computed tomography scanning of Meresamun*, **SPIE Newsroom**, 2009, DOI: 10.1117/2.1200904.1627, available online at http://spie.org/newsroom/1627-computed-tomography-scanning-of-meresamun, accessed on 09.05.2016.
[18] A. Otte, T. Thieme, A. Beck, *Computed tomography alone reveals the secrets of ancient mummies in medical archaeology*, **Hellenic Journal of Nuclear Medicine, 16(**2), 2013, pp. 148-149.
[19] H. Strudwick, J. Dawson, *Death on the Nile: Uncovering the Afterlife of Ancient Egypt*, **Catalogue of the Exhibition at the Fitzwilliam Museum, Cambridge, UK**, D. Giles Limited, London, 2016.
[20] N. Proietti, F. Presciutti, V. Di Tullio, B. Doherty, A.M. Marinelli, B. Provinciali, N. Macchioni, D. Capitani, C. Miliani, *Unilateral NMR, ^{13}C CPMAS NMR spectroscopy and micro-analytical techniques for studying the materials and state of conservation of an ancient Egyptian wooden sarcophagus*, **Analitical and Bioanalitical Chemistry, 399**(9), 2011, pp. 3117-3131.
[21] N.A.A. Bader, W.K. Al-Gharib, *Assessment of deterioration and conservation of a polychrome Wooden Coffin, from Al-Arish museum, Egypt*, **International Journal of Conservation Science, 4**(4), 2013, pp. 397-412.
[22] G. Quarta, S. Malgora, M. D'Elia, V. Gaballo, E. Braione, L. Maruccio, C. Corvaglia, L. Calcagnile, *The Strange Case of the Ankhpakhered Mummy: Results of AMS ^{14}C Dating*, **Radiocarbon, 55**(2-3), 2013, pp. 1403-1408.
[23] A. Abdrabou, M. Abdallah, M.A. El Kader, *Analytical study and conservation processes of a painted wooden Graeco - Roman coffin*, **International Journal of Conservation Science, 6**(4), 2015, pp. 573-586.
[24] S. Bracci, O. Caruso, M. Galeotti, R. Iannaccone, D. Magrini, D. Picchi, D. Pinna, S. Porcinai, *Multidisciplinary approach for the study of an Egyptian coffin (late 22nd/early 25th dynasty): Combining imaging and spectroscopic techniques*, **Spectrochimica Acta Part A, 145**, 2015, pp. 511-522.
[25] K.M. Garland, J. Bernstein, J. Rogers, *Raising Meret-it-es: Examining and conserving an Egyptian anthropoid coffin from 380-250 BCE*, **Journal of the American Institute for Conservation, 54**(2), 2015, pp. 102-113.
[26] A. Niwiński, *Sarcofagi della XXI dinastia. (CGT 10101-10122).* **Catalogo del Museo Egizio di Torino. Seconda serie - Collezioni, Vol. IX**, Torino, 2004, pp. 117-125, Tav. XXXIII.2, XXXIV, XXXV, XXXVI.
[27] E. Ferraris, C. Greco, *La galleria dei sarcofagi: dimore per l'eternità*, **Museo Egizio, Modena,** 2015, pp. 164-181, fig. 213.
[28] A. Niwiński, **21th Dynasty Coffins from Thebes**, Mainz (1988), §76, p. 79-80, n. 384, p. 172, pl. XIIA-B.
[29] K.M. Cooney, *Coffin reuse: ritual materialism in the context of scarcity,* **Proceedings of the First Vatican Coffin Conference**, Vatican Museums, 19-22 June 2013 (Edited by A. Amenta and H. Guichard), Edizioni Musei Vaticani, Città del Vaticano, 2013.

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