



5TH EDITION OF THE INTERNATIONAL MEETING ON RETOUCHING OF CULTURAL HERITAGE

UNIVERSITÀ DEGLI STUDI DI URBINO "CARLO BO"
SCUOLA DI CONSERVAZIONE E RESTAURO DEI BENI CULTURALI

18TH - 19TH OCTOBER
2019

Conservation and virtual reconstruction of the Lucanian Paintings from the National Archaeological Museum of Paestum (ITALY)

Ferrucci Fabiano, Maria Rita Ciardi, Amura Annamaria

Abstract: This contribution presents the restoration and virtual reconstruction of a painted tomb from the Lucan period (4th century BC), now dismantled and kept in the deposits of the National Archaeological Museum of Paestum. The virtual reconstruction that was carried out is based on several elements: identification of traces of the original color on the surfaces; pigment analysis; study of the execution technique; iconographic comparison with other painted pieces of the same corpus and reconstruction by levels (colored backgrounds, decorative elements; figurative elements). The video, which illustrates both the restoration intervention of the tomb and the virtual reconstruction, was presented at the RECH5 conference and it can be seen at: <https://www.facebook.com/officinabenculturali.info/videos/200967307895086>. It shows the different phases of the restoration work, such as cleaning and consolidation, and the subsequent reintegration of the virtual models, presenting how the intervention was carried out in a way that respects the authenticity of the work.

Keywords: virtual model, color reintegration, virtual reconstruction, Lucanian painting, mural painting restoration

Conservación y reconstrucción virtual de las pinturas Lucanas del Museo Arqueológico Nacional de Paestum (ITALIA)

Resumen: Esta contribución presenta la restauración e integración virtual de una tumba pintada del período Lucano (siglo IV a. C.) en la actualidad desmontada y conservada en los depósitos del Museo Arqueológico Nacional de Paestum. La reintegración virtual realizada se ha basada en los siguientes elementos: la identificación de los vestigios del color original en las superficies, el análisis de pigmentos, el estudio de la técnica ejecutiva, la comparación iconográfica con otras piezas pintadas del mismo corpus, y la reconstrucción por niveles (fondos coloridos, elementos decorativos y figurativos). El video, en el que se ilustra tanto la intervención de restauración real de la tumba como su reconstrucción digital, fue presentada en la conferencia RECH5 y puede ser visto en: <https://www.facebook.com/officinabenculturali.info/videos/200967307895086>. En él se muestran las distintas fases de restauración del trabajo, como la limpieza y consolidación, así como la posterior reintegración en modelos virtuales, mostrando cómo la intervención, llevada a cabo de esta forma, respeta los valores de autenticidad de la obra.

Palabras clave: modelo virtual, reintegración cromática, reconstrucción virtual, pintura Lucana, restauración de pintura mural

Conservação e reconstrução virtual das pinturas Lucanianas do Museu Nacional de Arqueologia de Paestum (ITÁLIA)

Resumo: Este artigo, apresenta os trabalhos de conservação e restauro e de reconstituição virtual, de um túmulo pintado do período Lucano (séc. IV a.C.), actualmente desmontado e conservado em depósito no Museu Arqueológico Nacional de Paestum. A reintegração virtual da obra teve por base diversos elementos: identificação de vestígios de policromia; análise de pigmentos; estudo das técnicas de execução; comparação iconográfica com outras obras do mesmo conjunto e reconstrução por níveis (cores de fundo, elementos decorativos e elementos figurativos). O vídeo, que ilustra os trabalhos de conservação e restauro e a reconstituição digital, foi apresentado na conferência RECH e pode ser visto em: <https://www.facebook.com/officinabenculturali.info/videos/200967307895086>. São abordadas diferentes fases dos trabalhos, como a limpeza e a consolidação, e a conseqüente reintegração cromática através de modelos virtuais, mostrando como uma intervenção virtual respeita os valores de autenticidade da obra.

Palavras-chave: modelo virtual, reintegração cromática, reconstituição virtual, pintura Lucana, restauro de pintura mural

Introduction

—*The Lucan painting tomb, executive technique, and degradation*

The National Archaeological Museum of Paestum, preserves about five hundred painted slabs and fragments of slabs, mainly from tombs of the Lucan period (5th – 3rd century BC), recovered from necropolises during the first decades of the 20th century. (Pontrandolfo and Rouveret 1992; Pontrandolfo 2002). Together with the Etruscan painting, these painted slabs are the most important collection of pre-roman paintings in Italy (Brekoulaki 2001). They are stone cases, painted inside, executed with travertine slabs, which act as walls and roofs. The travertine was extracted directly from the bedrock on which *Poseidonia* was built. The recurrence of iconographic themes on the Paestum paintings, such as battles between mythological animals, the preparation of the body of the defunct and funeral games of combat, are rich in variations and in details, reminding of a mnemonic execution or the possible use of drawing albums present in the workshop.

Based on the macroscopic observations and on the laboratorial analyses, it was possible to confirm the presence of lime-based plasters, painted when the surfaces were still wet. The numerous visible signs on the surfaces, which disfigure the plaster and the color, indicate unequivocally that the deceased and the grave goods were laid with the walls recently plastered and painted. The paintings were executed to be shown during the ritual and then the tomb was closed. This points to the use of a fast method, without tracing any preparatory drawing. The color palette was limited, being red the most used color. The plinth, present on almost all of the graves, is red and in only two cases, black. The red color, based on the results of the laboratory analysis, consists of red ocher; the yellows, only point to the use of yellow ocher; the white is obtained, in most cases, by leaving the color of the plaster exposed and it is also typically used to lighten other colors. The only white pigment used with certainty is white lime, obtained by finely grinding the slaked lime after drying it. Blue is used only in a few graves and always in minimal areas; the analysis reveals a constant composition, with characteristics similar to those of Egyptian Blue. The black pigment used to the greatest extent is carbon black. Green is a color that is almost entirely absent, although there is no lack of a reason to use it: vegetable elements on almost all the slabs of *Paestum* are depicted in abundance. The rare cases of green tones identified and analyzed in the past, belonging to the group of *Paestum* and from other archaeological sites in Campania, revealed a combination of Egyptian Blue, with black and ocher [table 1]. However, it was found fleeting traces of a fluorescent material, that suggests the use of green vegetable dyes, that would alter rapidly due to the caustic reaction with the lime (Ferrucci 2005).

Most of the degradation phenomena derive from the fact that the tombs were closed too soon after the burial. The process of drying the plaster, carbonation and fixing of the colors took place abnormally. In general, the preparatory layer of the paints presents severe phenomena of de-cohesion.

Table 1.- Materials identified and analyzed in the past on tomb paintings.

Colors	Pigments and dyes
Red	Red Ocher
Yellow	Yellow ocher
White	White of lime
Blue	Egyptian Blue
Black	Carbon Black
Green	Green vegetable dyes (?)

Carbonate incrustations, of white or black color, cover the pictorial film. The underlying plaster is extremely porous and fragile, as calcium carbonate has migrated to the surface. The concretions that create the major image reading problems are the black ones. They consist of microscopic fungi, which developed in the first phase of burial, due to the presence of organic material inside the sepulcher. The fungi then underwent an anaerobic carbonation process, that incorporated them into surface concretions (Di Cosimo and Ferrucci 1994).

— *Restoration of the Lucan tomb painting*

The restoration of the Lucanian paintings began to be studied with scientific criteria in 1987, when a pilot project was carried out by the Central Institute for Restoration in Rome. In 1987, the restorers, authors of this text, Fabiano Ferrucci and Maria Rita Ciardi, were students of the Institute and participated in the first pilot site. Since then, reunited in the company L'Officina Consorzio, they have carried out most of the interventions, specializing in the restoration of these artifacts, which have quite peculiar problems.

The most numerous findings date back to excavations carried out in the decades of 60 and 70, from the 20th century and were so numerous that they filled the museum's deposits. In 2005 the deposits were therefore reorganized. The painted slabs were placed on specially designed sliding trolleys. This allowed to better study, restore and carry out periodic maintenance, and in the case of the Lucanian paintings, also allowed visitors to view them.

Until the seventies, the interventions had been carried out with unsuitable materials: gypsum, cement, and with Vinavil® dispersion (Vinavil S.p.a). Presumed missing parts of the images were also painted with those materials. Tombs excavated before the 1950s had often been treated with wax.

This changed in the second half of the 80s, when the interventions avoided the integration of the images. The aim was to allow the correct reading of the works, in order for the archaeologists to study the paintings without anything added to what was left of the original images, safeguarding the authenticity of the image and the subject.

The restoration of Lucanian paintings, in general, is divided into documentation, interventions on stone, interventions on plaster and the color scheme. The consolidation focuses primarily on the crystalline structure of the plaster, without which the cleaning and removal of incrustations and extraneous material could not be performed. The cleaning alternates mechanical and chemical methods, and is completed with the extraction of any residual soluble salts; the aim is to preserve and to read the image. The total removal of any foreign element to the original material could compromise the original color of the work (Amadori et al. 2005).

In some of the slabs the painting was almost totally lost and only minimal traces of color remained, sometimes only incisions. Slabs that, according to Brandi's theory (Brandi 1997), are define as "ruin" because the formal features were lost or almost completely lost. In 2005 the authors began experimenting with the virtual reconstruction of these slabs reduced "to the state of ruin."

— *Case-study: the Spina Gaudio Tomb 418/2011*

Tomb 418 was found in the Necropolis of Spina Gaudio, near Paestum, in 2011 (Di Gregorio and Granese 2017). The tomb is of the double sloping roof type. The interior space is about 200 cm long and 136 cm wide and its maximum height is about 150 cm. The longer sides are each made from a single slab, about 25 cm thick, while the short sides consist of two blocks: a lower rectangular one with a height equal to the slabs of the long sides, while the upper triangular block acts as a cusp. Two blocks were superimposed on the short sides. The soil fill ensured static rigidity.

The plaster was very weak; this being the most critical type of plaster degradation among those that are generally found in the tombs of Paestum. Despite the widespread phenomenon of lifting, abrasion and loss of color, the image was still largely saved, under layers of carbonates and earthy concretions. The pictorial film was incorporated in the superficial carbonated layer, together with oxides and impurities that migrated from the substrate, or that came from the internal environment of the burial.

The scenes depicted in the slabs are: a fight between imaginary animals (Gryphon and Panthera), on the short sides [figure 1c] [figure 6c-d]; the exposure of the body of the deceased and the mourning of women [figure 4b] and a duel on the southernmost side with a winged Victory arriving on a chariot [figure 5b]; all decorated with plants, palmettes and pomegranate fruits.

The tomb restoration and the virtual reconstruction were carried in 2016, with the contribution of the Italian American Forum.

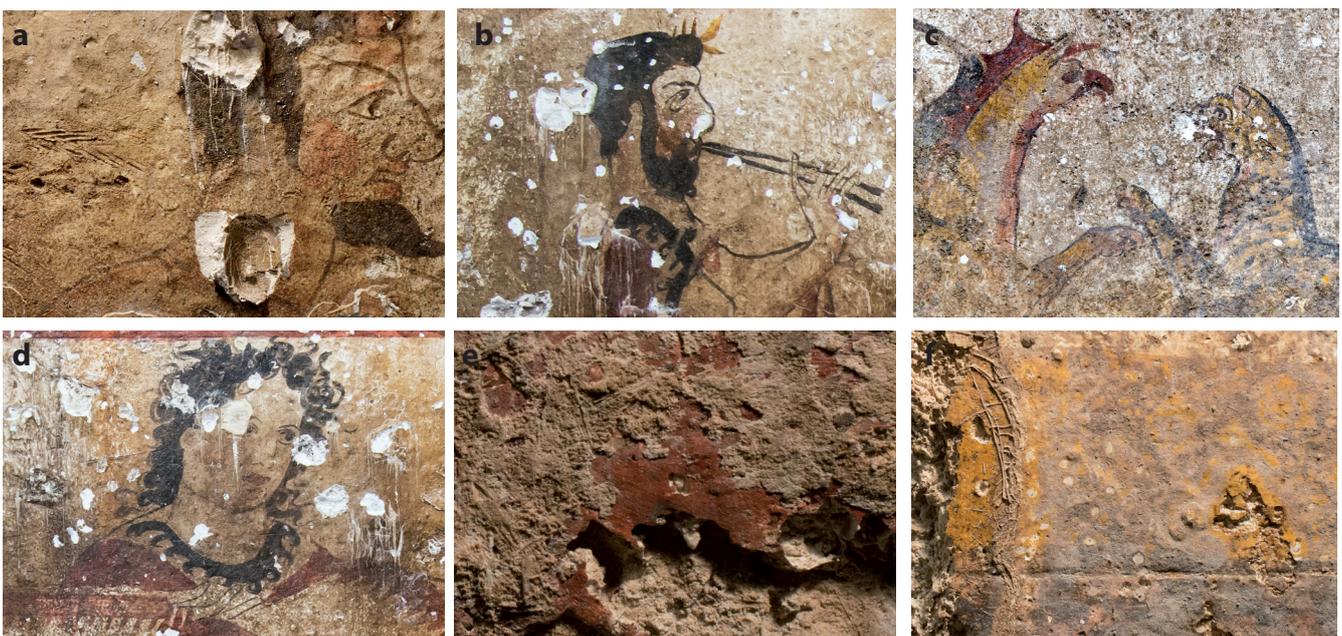


Figure 1. - Details of the Tomb 418. (a) South Slab. Face of a warrior; (b) North Slab. Face of a musician; (c) East Slab. Fight between Gryphon and Panthera; (d) Detail of North Slab scene; (e) Traces of original red ocher; (f) Traces of original yellow ocher. ©Annamaria Amura.

A distinctive feature of this tomb is that the imprints of the fabric have been found fixed and impressed in the plaster [figure 1a]. The primary operations carried out were: removal of deposits, dust and excavated earth; consolidation of pictorial film detachments; cleaning and consolidation of the travertine base; consolidation of the crystalline structure of the plaster; cleaning of the pictorial film, alternating mechanical and chemical methods and micro-grouting of the plaster micro-fractures - these fillings have the function of supporting the preparatory layer and are an effective way of stopping the disintegration of the plaster. The final aesthetic-rendering phase of the image, followed the general approach to the problem of conservation and restoration of Campanian-Lucanian painting, as it was defined at the end of the 1980s. It privileges conservation, safeguarding the authenticity of the artifacts, thus excluding integrative operations of the image, directly performed on the artifact.

this operation allows us to have a view of what the originally painted images looked like, without distorting their authenticity. It is essential to base the virtual intervention on information that is actually present on the surface of the work, without inventing information that cannot be reconstructed, so as not to excessively alter the aesthetics of the artwork (Althofer 2002; Amura 2014). Tomb number 418, preserves much of the original drawing, figures and colors. The photographs in visible light, taken after the conservation work, make it possible to well-read the depicted subjects. This characteristic has allowed a faithful figurative reconstruction of almost 90% of the images. Some missing details, such as the face of the horse in the south slab and the eye on the face of the woman in the north slab, have been reconstructed, taking as example an analogous element present in the representation itself. Part of the winged Victory's face was totally lost; in this case, it was not reconstructed, as it would have been a completely arbitrary result.

Virtual intervention

To promote the preservation of the pictorial film and make the drawing legible without damaging the original, it was decided not to reintegrate the image, but to restore it using virtual models, processed with a computer graphics operation called “virtual iconographic restoration” (Bennardi and Furferi 2007). With this expression, it is possible to identify an iconographic reconstruction or color enhancement, mainly carried out on the image of the work, on its photographic reproduction (Cappellini 1979, 1985; Biagi and Maino 2017). The purpose of iconographic restoration is to bring the image of the work back to its original stage, or to analyze, by means of proposals, the intermediate phases, for example, by virtually eliminating the alterations suffered over time (Stanco et al. 2011, Limoncelli 2011). Therefore,

— *Step 1: graphic documentation*

The best practices for virtual intervention are undoubtedly based on the careful reconstruction and graphic documentation. In fact, all the information regarding the artwork's state of conservation is localized and transcribed graphically into vector drawing documents called thematic maps. These are the primary tools to preserve, communicate and synthesize all the information collected (Sacco 2002; Amura et al. 2019). These documents provide a basis for the conservation and restoration processes. In this case, the virtual iconographic restoration was preceded by detailed graphic documentation, in order to identify and circumscribe all lacunae before the intervention. The vector drawing was executed by tracing the original lines visible on the surface [figure 2].

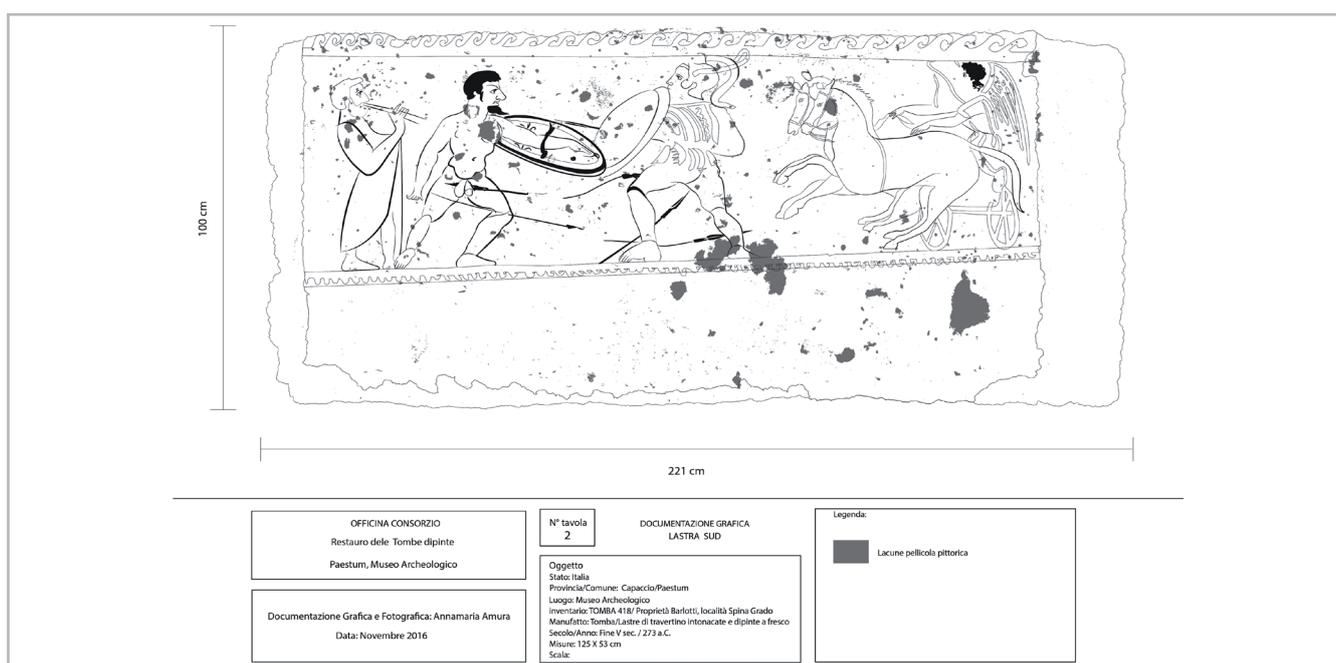


Figure 2.- Thematic mapping, state of conservation and graphical drawing of the lacunae in the north slab. ©Annamaria Amura, 2019.

— *Step 2: spatial analysis*

By reading all traces of color on the slabs, through an iconographic comparison with other graves in the museum, and based on the knowledge of the colors and the technical procedures, it was possible to restore the color of Tomb 418 virtually. The virtual iconographic restoration color proposals, were created choosing neutral tones with a zonal statistical mean function in MatLab®. It was then calculated the mean value based on the areas of color that didn't have a chromatic alteration, obtaining a set of three RGB values, which represent the mean of the colored pigment of the original surface painting on the tomb (McAndrew 2004; The Mathworks 2019).

— *Step 3: virtual iconographic restoration proposal*

The virtual iconographic restoration proposals for the tomb's color were performed with Adobe® Photoshop® CC2019, using the technique of "replacing color"; the RGB values were changed in the areas of the plaster where the color had been lost, by the RGB values obtained from the statistical mean, in order to maintain the texture but also to eliminate all the chromatic alterations.

In Tomb 418, the range of pigments is restricted. The white elements use the color of the plaster, circumscribing it in black or red. The pigments are: carbon black, smoke black, bone black, red ochre, white lime and yellow ochre. The lines of the drawing in black were selected with the "slicing segmentation" algorithm in Photoshop® CC2019, to allow an increase in contrast of the image in order to restore its original color (Adobe® Photoshop® CC Help 2018, Gonzalez and Woods 2012). In the virtual reconstructions [figure 4c, figure 5c and figures 6e-f] it's possible to appreciate the rapid style of painting, which defines the fields and the lines that built the scenes through few uniform colors. The images of the iconographic restoration thus created, were projected on the mesh surface of a three-dimensional model made with Autodesk™ plus 3DS MAX© software [figure 3].



Figure 3.- 3D Virtual Reconstruction of the Tomb 418, executed by Salvatore de Stefano (s.d.s. grafica, Napoli). (a)(b) Typology of tombs with a double sloping roof. Image before restoration; (c) Tomb 418. Image after restoration; (d) Tomb 418. Image of the virtual iconographic restoration proposal



Figure 4.- Tomb 418. Slabs of travertine plastered and freshly painted. Paestum Archaeological Museum, Barlotti property, Spina Gaudio area. North side slab scene: the exposure of the body of the deceased and the mourning of women. 125 x 53 cm. (a) Photo before restoration; (b) Photo after restoration; (c) Virtual iconographic restoration proposal. ©Annamaria Amura, 2019).

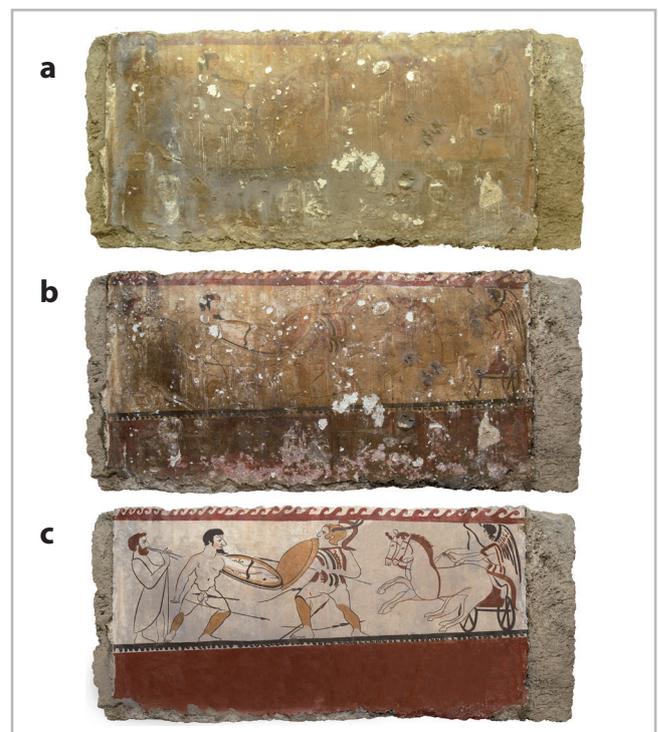


Figure 5.- Tomb 418. Slabs of travertine plastered and freshly painted. Paestum Archaeological Museum, Barlotti property, Spina Gaudio area. South Slab scene: a duel on a winged Victory arriving on a chariot. 125 x 53 cm. (a) Photo before restoration; (b) Photo after restoration; (c) Virtual iconographic restoration proposal. ©Annamaria Amura, 2019).

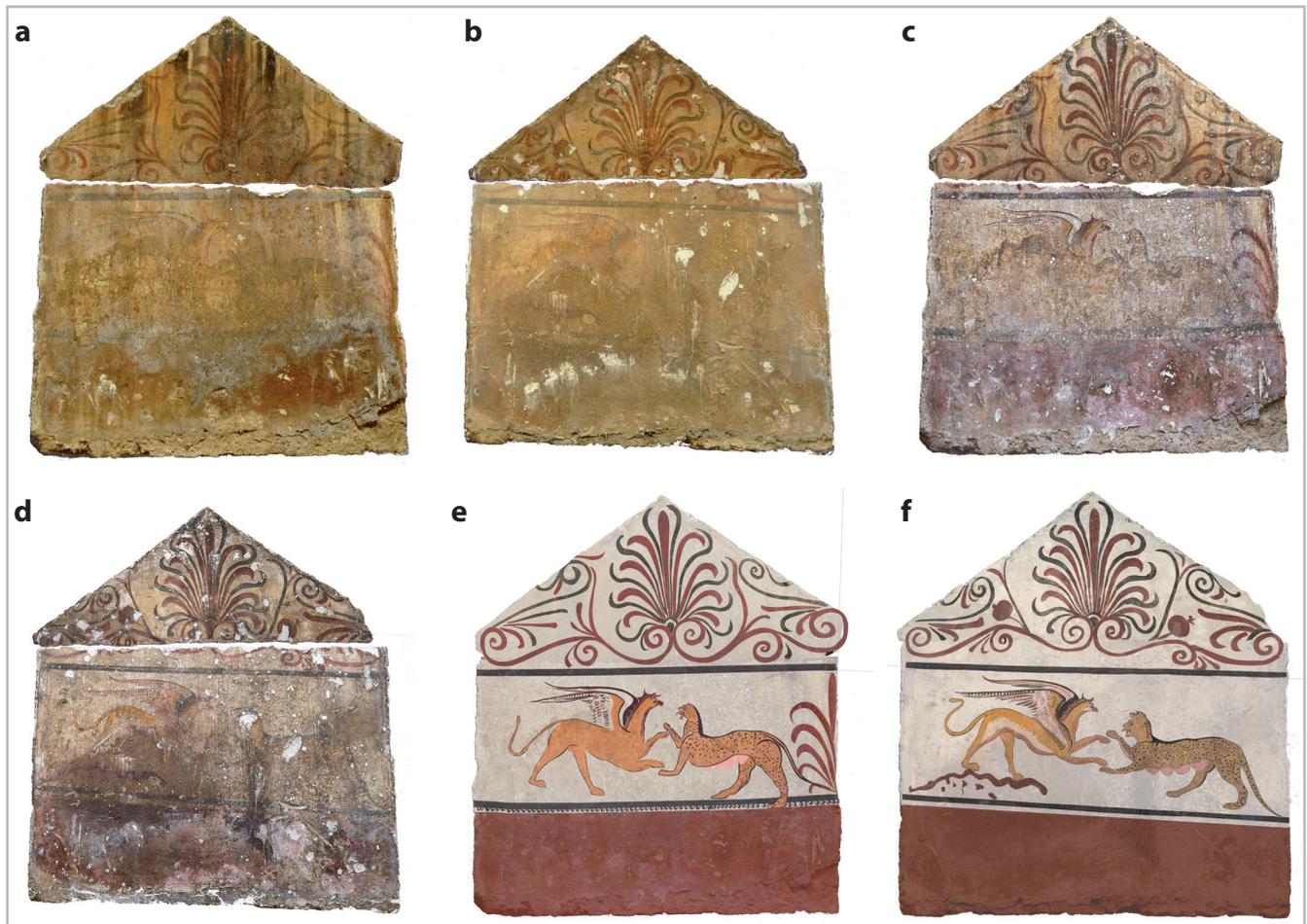


Figure 6.- Tomb 418. Slabs of travertine plastered and freshly painted. Paestum Archaeological Museum, Barlotti property, Spina Gaudio area. East and West Short Side Slabs: the fight between the mythical animals' Gryphon and Panthera, decorated with plant elements, palmettes and pomegranate fruits. (a)(b) Photo before restoration; (c)(d) Photo after restoration; (e)(f) Virtual iconographic restoration proposal. ©Annamaria Amura, 2019).

Conclusions

Starting from the second half of the 1980s, the restoration of the painted tombs of Paestum began to be tackled with scientific criteria and methodologies. Before then, the missing parts of the depictions were artistically reconstructed directly onto the originals, causing a falsification of the image. Since the 1990s, numerous tombs have been restored by the Officina Consorzio of Rome, avoiding the integration of the image; this allows a correct reading of the works by the archaeologists, in order for them to study the paintings correctly, safeguarding the authenticity of the image.

Since 2005 we have begun experimenting with virtual reconstruction on digital models. By intervening in the digitized image, it is possible to optimize the readability of the work without resorting to traumatic or irreversible interventions on the original. A maximum freedom of action is achieved, since it operates on digital information that can be modified without any consequence for the original.

The traditional conservation and restoration of the work

consists mainly of consolidation and cleaning, while the integrative phase of the image takes place on digital models. Therefore, virtual reconstruction is an integrative experience of physical methodologies. The case study of Tomb 418, from the Necropolis of Spina Gaudio, shows how to obtain a scientifically virtual reconstruction with criteria. However, some fundamental steps must be performed: identification of traces of the original color on the surfaces; pigment analysis; study of the execution technique; iconographic comparison with other works of the same corpus and reconstruction by levels (colored backgrounds, decorative elements and figurative elements).

The interpretation work must be performed by the direct observation of the originals (not in photos), by a team with the skills to do so: restorers, archaeologists and analysis experts. Graphic designers should be asked to develop a graphic model based on photographic documentation and geometric measurement. The synergy between different professionals, respecting competencies, leads to a scientifically correct result (which in our case was a video), usable for study, didactic and with informative purposes.

Acknowledgments

For having promoted and allowed the success of the intervention of restoration and valorization of the Tomb 418_2011, of the necropolis of Spina Gaudio, the authors wish to thank: Museo Archeologico di Paestum; the Director of the Park, Dott. Gabriel Zuchtrigel; Rest. Raffaele Cantiello; Rest. Rosario D'Andrea; Rest. Daniela Rosa; 3D Virtual reconstruction Salvatore De Stefano, s.d.s Grafica, Napoli; Video Documentary Voices, Giovanni Amura.

Funded with the contribution of the ITALIAN AMERICAN FORUM.

In particular, we would like to thank Dr. Marina Cirpiani, who excavated the tomb in 2011 and worked to make its restoration possible.

Notes

The laboratorial analyses were carried out by Maria Letizia Amadori, researcher and lecturer, at the Department of Pure and Applied Sciences, University of Urbino Carlo Bo, Piazza Rinascimento n. 6, Italy. (maria.amadori@uniurb.it)

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Author/s



Fabiano Ferrucci

fabiano.ferrucci@gmail.com

Restorer of Cultural Heritage; Professor at the School of Conservation and Restoration, University of Urbino.

Graduated from the Central Institute for Restoration in Rome in 1989, followed by an ICR specialization course in 1992. Graduated with honors in Art History at the University of La Sapienza. Directed important restoration sites in Paestum, Ostia Antica, Ercolano, Pompei and the Imperial Fora in Rome. He has been working on Campanian-Lucanian painting for 30 years. Since 2001 is a Professor at the University of Urbino. Author of 40 scientific publications



<https://doi.org/10.37558/gec.v18i1.852>



Maria Rita Ciardi

ritacia2001@yahoo.it

Restorer of Cultural Heritage; Professor at the School of Conservation and Restoration, University of Urbino.

Is a graduate restorer from the Central Institute for Restoration in Rome. She is currently Professor at the School of Conservation and Restoration, University of Urbino. She is also the author of several scientific texts about conservation and maintenance programs for archaeological monuments. Since 1990, is the legal representative and technical director of L'Officina Consorzio di Roma. She works for several Italian Superintendencies in important archaeological areas such as Paestum, Palatino, Ostia Antica, Nora, and for the Vatican Museums. Works on projects and technical direction, and provides consultancy for restoration activities.



Annamaria Amura

annamaria.amura@uniurb.it

Ph.D Candidate in Computer Science at the Department of Pure and Applied Sciences, University of Urbino Caro Bo.

Ph.D. Candidate in Computer Science at the University of Urbino, with a research project in "Digital Image Analysis for the Automation of Graphic Documentation of Cultural Heritage." She has had several teaching supports contracts in computer science and design courses. She has a B.d. in Technology for the Conservation and Restoration of Cultural Heritage, Class 41, and a M.d. in Graphics of Images, LM12, Documentation and Photography for Cultural Heritage. Her research interests include digital photography, image analysis, features extraction from diagnostic images, raster to vector automation method, GIS databases, virtual restoration and graphic documentation.