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### Édition électronique

URL : <http://journals.openedition.org/ceroart/3197>

DOI : 10.4000/ceroart.3197

ISSN : 1784-5092

### Éditeur

Association CeROArt

### Référence électronique

Helena Pereira, « Saint John at Calvary: technical and material study of a polychrome wood sculpture », *CeROArt* [En ligne], EGG 3 | 2013, mis en ligne le 10 mai 2013, consulté le 02 mai 2019.

URL : <http://journals.openedition.org/ceroart/3197> ; DOI : 10.4000/ceroart.3197

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# Saint John at Calvary: technical and material study of a polychrome wood sculpture

Helena Pereira

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*To Direcção Geral do Património Cultural (DGPC), for the internship program and to the Laboratório José Figueiredo, Direcção de Museus Conservação e Credenciação and Hercules Laboratory, for the exams and analysis carried out.*

*To Carla Rego (MSc) and Elsa Murta (MSc) for the supervision and support.*

*To Dr. António João Cruz, for being available to review this article.*

## Introduction

- 1 Saint John at Calvary (Fig. 1) is a polychrome wood sculpture from the National Museum of Ancient Art, Lisbon. It came from the Commander Ernesto Vilhena collection, a private collection with unknown primitive origin. It is a small sculpture (69.3 cm high and 24.7 cm wide) that belonged to a Calvary scene, from which only the Virgin figure remains besides Saint John.

Fig. 1 Saint John



Saint John from a Calvary scene, front view.

Credits: João Piorro, Divisão de Fotografia e Radiografia do Laboratório José de Figueiredo.

- 2 Several features suggest that it is a Portuguese work from the 17<sup>th</sup> century. Relatively to its shape, the presence of compact volumes transmitted through the use of heavy drapery which hides the body shape, allied to a hieratic position and to a slightly elaborated drapery are in accordance with the norms of the Catholic Reformation prevailing at national level (Dias, 1995). Despite this, it is an artwork that exhibits a high level of drama and expressivity. Regarding to the decoration, this sculpture shows the *estofado* and *esgrafitado* (scratched) technique, exhibiting a decorative pattern with vegetal motifs in the red mantle, remembering an imitation of damask tissues, commensurate with the most popular decoration in the seventeenth century, period where the vegetal motifs were preferred instead of grotesque motifs widespread in the previous period (Espinosa, 2002). The green tunic exhibits a geometric pattern. Unfortunately during the research similar patterns weren't found in sculptures of the same period, which does not mean that similar patterns don't exist. The simple *esgrafitado* technique was largely used during 16<sup>th</sup> century, also crossing the 17<sup>th</sup> century (Serck-Dewaide, 2002).
- 3 The state of conservation was reasonable although some problems were found. Regarding to the wooden support, the existence of profound clefts and fissures led to the existence of previous restorations that were not carefully done, namely the rigid white paste filling the support's clefts, the overpaintings that largely exceeded the limits of the polychrome lacunae, the presence of a thick, yellowish and dirty protective layer, composed by a diterpenic resin, and finally the addition of a wooden base, fixed with metallic elements that were oxidized.

- 4 The sculpture has undergone conservation treatment, which was preceded by a study of the materials and techniques employed and its conservation state. This study was considered fundamental for the preparation of an adequate treatment proposal including the selection of appropriate materials to apply and treatments to be performed. Moreover, it was considered that this study could also contribute to the characterisation of the Portuguese polychrome wood sculpture from the 17<sup>th</sup> century about which very little is known (Dias, 1995), (Alves, 2002). The presentation of this study is the objective of this paper.
- 5 The study and the conservation treatment took place at the Direcção-Geral do Património Cultural (Lisbon, Portugal) in the framework of a curricular internship for the completion of a Master Degree in Conservation and Restoration of the Polytechnic Institute of Tomar.

## Analytical methods

- 6 The superficial observation of the sculpture was made with a binocular magnifier from Stéréomicroscope SMXX, Carl Zeiss Jena. Ultraviolet fluorescence photography was obtained with an analogical camera with photographic film and color correction filter Mamiya RZ 67, and the radiographs with an Yxlon International Andrex Smart 160 E X-ray source with a Kodak Industrex AA 400 film ready pack.
- 7 For identification of the wood support, histological analysis was carried out with a microscope Leitz Wetzlar. Micro-samples taken from the paint layers, embedded in an epoxy resin from Struers, were also studied in the same optical microscope. These samples were also analysed with scanning electron microscopy with X-ray spectrometry (SEM-EDS) with a variable pressure scanning electron microscope Hitachi 3700N, operated at 20 kV, in BSE mode and with a Bruker Contact 200 EDS detector.
- 8 For identification of the pigments and the binding-media, micro Fourier transform infrared spectrometry ( $\mu$ -FTIR) has been used with the aid of an IR spectrometer Nexus 670 FTIR Thermo Nicolet with a infrared microscope Continuum Thermo Nicolet ATR accessory (slide-on ART Spectra-Tech) and a diamond compression microcell from Spectra-Tech. For identification of some pigments, Raman spectroscopy was also used. The equipment used was an Horiba Xplora with focal Micro Raman (638 and 785 nm lasers) with CCD detector coupled with an Olympus camera BX41.
- 9 The SEM-EDS and Raman analysis were performed by Hercules Laboratory (Évora) while the other analyses were made by Direcção-Geral do Património Cultural (José de Figueiredo laboratory and photography and radiography services).

## Results

### Wooden support

- 10 Through the histological analysis it was possible to observe the characteristics of the cellular structure of what is probably cedar wood – *Cedrus sp.*, a gymnospermic plant from which we could not conclude to what species it belongs to (Fig. 2).

Fig. 2 Wood sample



Longitudinal cut of a wood sample observed by optical microscopy (400 $\times$ ).

Credits: Lília Esteves, Laboratório José de Figueiredo.

- 11 According to the visual observations and to the radiographs (Fig. 3a), the sculpture is composed of three wooden blocks, joined by simple assembly (Fig. 3b). A central block constitutes the majority of the work's volume and two smaller ones correspond to the tip of the left foot and to the left shoulder.

Fig. 3 Radiograph and correspondent sketch of the assembly

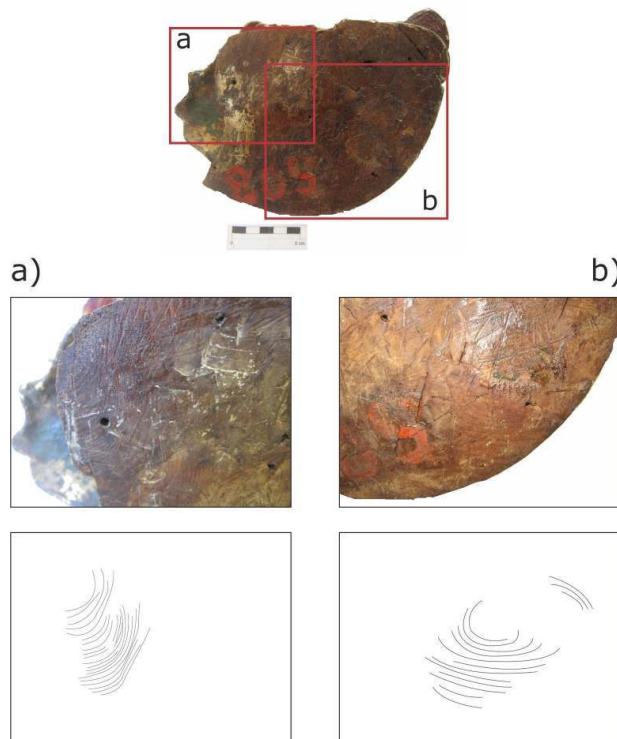


a) Radiograph showing the union areas, also revealing some conservation issues: fissures and clefts; the presence of different materials applied, consequence of posteriors interventions such as the paste filling the support clefts, overpaintings and the application of metallic elements. b) Sketch of the assembly.

Credits: a) Luis Piorro, Divisão de Fotografia e Radiografia do Laboratório José de Figueiredo. b) N/A.

- 12 The sculpture was carved in the longitudinal direction of the wood, as advised (Baudry 1984), and it is likely to have been performed in three stages. In first place, a general thinning was made with chisels, which left marks on a hidden area of the original base, where there has been no smoothing treatment. In the second stage the volumes were defined. In general, gouges were probably used, such as in the drapery; in other more delicate details, for instance hands and nails, tools that enable a more accurate work (such as burins) might have been employed. In the third stage, some abrasive materials were used on the wood, making it flawless, as revealed by the very smooth wooden surface observed in some lacunae without the ground layers.
- 13 The radiograph shows that, the wooden block was not hollowed, which is a common factor in sculptures of small dimension (Serck-Dewaide 2002). Although there was some caution with the choice of the wood, which contributed to the absence of signs of microorganism attack, some structural problems presented by the chosen specimen were not taken into account. As observed in the original base of the sculpture, the wood has been obtained from an area of the trunk with two piths (Fig. 4), a situation that results from the formation of a new branch.

Fig. 4 Photo and sketch of the tree rings at the base of the sculpture



Through this sketch we can verify the existence of growth rings with opposite directions.

Credits: N/A

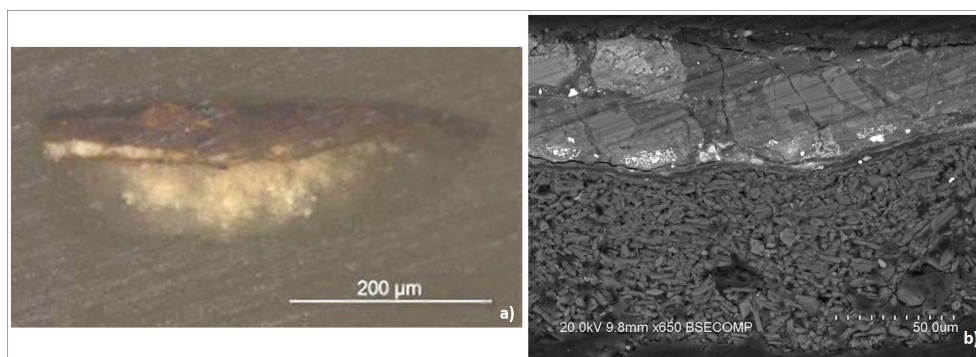
- 14 In the place from where the central block was cut, the separation of the branch from the trunk did not happened, but the deviations in the direction of wood fibres cause a decrease in the strength and resistance (Cerver 1989) that contributed to the formation of cracks and fissures presented by the sculpture.

## Ground layer

- 15 According to the sample taken from the hair zone (Fig. 5), the ground layer is mainly formed by calcium, oxygen and sulphur compounds (SEM-EDS). The  $\mu$ -FTIR analysis showed the use, as expected, of calcium sulphate and a protein medium. This mixture, essential for the subsequent decorative work, was common at the time in Portugal (Serck-Dewaide 2002).

Fig. 5 Sample taken from the hair area.





Optical microscopy: cross section of a sample taken from the hair area. b) Backscattering electron image, SEM-EDS of the respective cross section of the hair.

Credits: a) Laboratório José de Figueiredo. b) Hercules Laboratory.

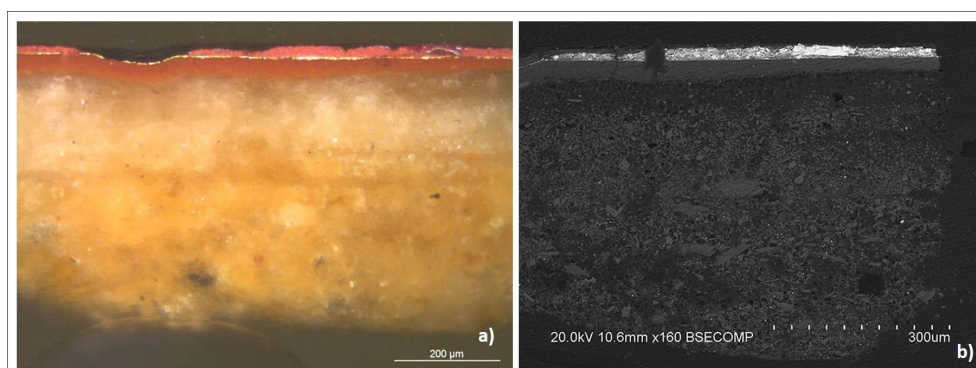
- 16 This ground layer would be probably preceded by some coats of animal glue (named *encolagem*), making the wood support more receptive to the following layers.
- 17 In the set of stratigraphic samples, the ground layer seems to be heterogeneous, constituted mostly by particles with a small size mixed with some coarse particles, some of which are black particles with very large dimensions. These black particles do not appear in the sample of the flesh area, and this could mean a different criterion in the selection of mixtures for that area. According to the SEM-EDS images, the fine particles have angular shape and homogeneous size (Fig. 5b).
- 18 According to the results obtained by optical microscopy (stratigraphic samples) and observations with the binocular magnifier (lacunae in the surface), the ground layer seems to be composed by a different number of strata which is related to the area of the sculpture. In the red mantle and in the green tunic areas, the ground seems to be composed by two strata. The lower has a more yellowish shade and coarser particles than the upper strata. Probably, they correspond, respectively, to the strata of *gesso grosso* and *gesso mate*, mentioned in the literature (Serck-Dewaide 2002). In the other areas, only one stratum was detected. In the specific case of the flesh area, this single stratum can be related to a common practice characterised by the use, in that area, of fewer and thinner strata composed by fine particles that allow the attainment of a fine, smooth and uniform surface necessary for the realism of the representation. In the sculpture under study the thickness of the ground layer in the flesh sample is about 16 µm, in contrast to the thickness of the ground in the other samples that varies between about 70 µm and 430 µm.

## The gilding

- 19 Observing the stratigraphic samples with an optical microscope it seems that the presence of a homogeneous and thick layer (about 24 µm) with reddish colour and fine-grain arises immediately over the ground layer (Fig. 6). This layer was observed in samples collected from gilded areas, namely mantle, tunic, sandals and original base. Considering the mentioned properties and its position immediately below the gold leaf, this layer can be identified as the bole layer, which provides the adhesion of gold leaf, implying necessarily the water gilding process (Letona 2004).



Fig. 6 Sample taken from the mantle area.



Optical microscopy: a) cross section of a sample taken from the mantle area, where we can see a typical cross section of *estofado* technique. Notice that the ground layer seems to be composed by two strata. b) Backscattering electron image, SEM-EDS of the respective cross section of the mantle.

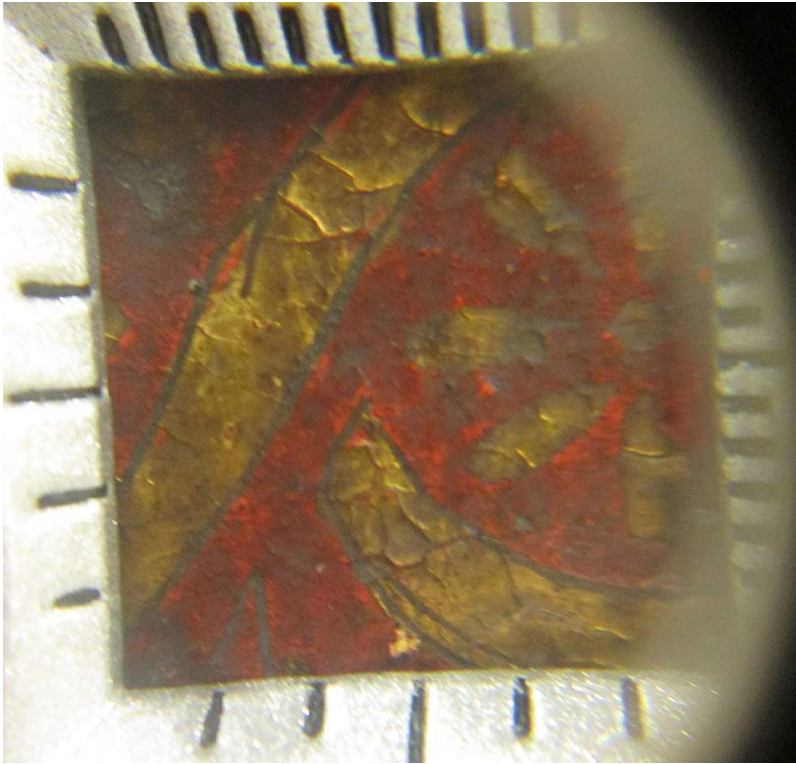
Credits: a) Laboratório José de Figueiredo. b) Hercules Laboratory.

- 20 According to the  $\mu$ -FTIR analysis, the layer is composed by ochre bonded with a protein medium. By EDS analysis, besides the iron compounds, a significant concentration of aluminum silicates was detected, which confirms the presence of a bole.
- 21 The gold leaf, which has a burnished finish, was analysed by SEM-EDS. In average, it is about 107 nm thick and is composed of about 94 % of gold, 2 % of silver and 4 % of copper, revealing to be a gold leaf of high quality. This factor comes to confirm previous studies (Serck-Dewaide, 2002) that had already shown that the polychrome sculpture, as the gilded woodcarving, could also have a gold leaf of high quality even if the sculpture posteriorly *estofada*, so the gilding process would be mostly hidden.

## Red estofado

- 22 In the red mantle, white lead and a protein medium have been identified through  $\mu$ -FTIR and the use of vermilion was detected through SEM-EDS. By optical microscopy, was verified that this superficial stratum was applied directly over the gold leaf and it is characterised by its homogeneity and irregular surface. It has an average thickness of 22  $\mu$ m. The use of tempera technique and the use of the mixture of white lead and vermilion are in agreement with what could be expected based on the technical sources of the time (Nunes 1615).
- 23 According to the *estofado* technique, over this leaf the paint layer was applied which, after dried, was scratched in order to create a decorative pattern composed by motifs that could be made freely by the author. However, in the present case, some of the motifs do not seem made freely over the surface, but seem to follow a pattern based on a pre-existing model (for example, an engraving or a drawing). This is suggested by the pattern itself and mainly by the incised marks observed in the gold leaf at the mantle boundary (Fig. 7). Sometimes these models were passed through paper and charcoal, but here and in other cases (Letona 2004) the incision process seems to have been used.

Fig. 7 Magnified image of a motif of the mantle boundary



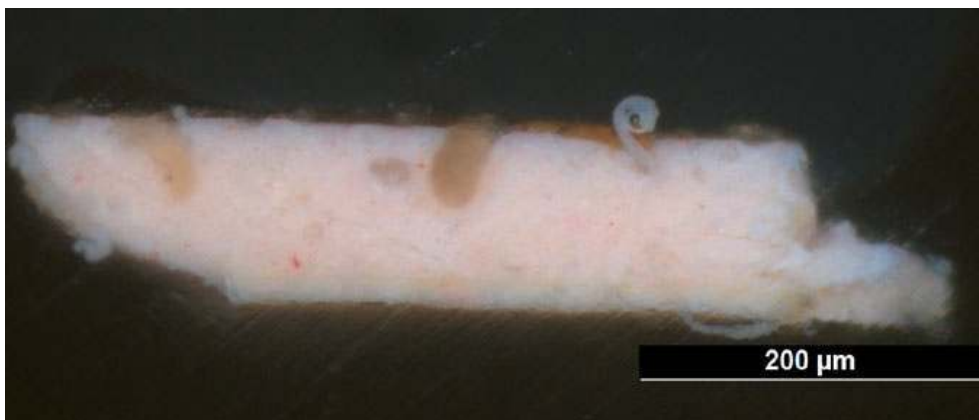
Incised marks at the mantle boundary area observed through a magnifier. Notice the black contour.

Credits: N/A

## Flesh colour

- 24 The flesh colour is due to a pink stratum (Fig. 8), directly applied over the ground layer, with a thickness of about 80  $\mu\text{m}$ . It is very compact and homogeneous, although exhibiting some red particles with larger dimensions.

Fig. 8 Sample taken from the flesh colour area

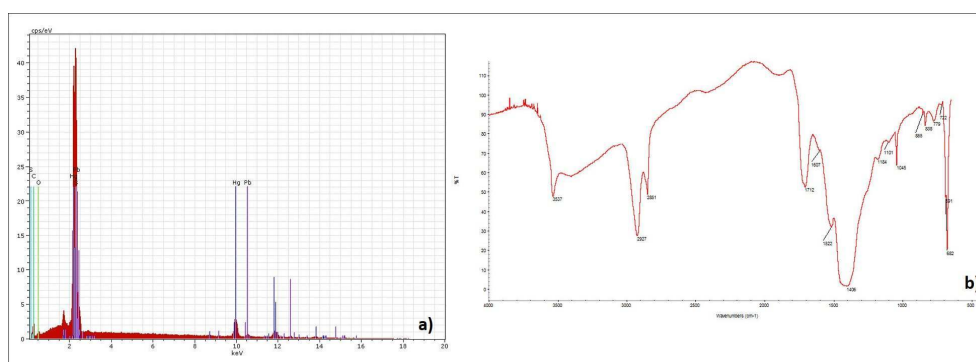


Cross section of a sample from the flesh color area, through optical microscopy. The first layer corresponds to ground layer, the second to the flesh color and the third to a diterpenic resin

Credits: Laboratório José de Figueiredo.

- 25 By SEM-EDS mercury, sulphur and lead compounds were detected (Fig. 9a). Mercury and sulphur show the use of vermillion ( $\text{HgS}$ ) and the lead compound, according to the  $\mu$ -FTIR spectrum is white lead ( $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$ ).
- 26 With the brush tip, the painter has defined the contours and colours of the eyes, eyelashes, eyebrows, nails, lips and even tears, the later applied with white paint. According to the literature, these details and different gradients were made with the ink still fresh, otherwise the ink tends to break (Goñi 1990).
- 27 The  $\mu$ -FTIR spectrum (Fig. 9b) shows also the presence of oxalates and carboxylates that can be explained by the reaction between white lead and an oil medium (Loon 2008). The use of oil was also expected and, after polishing, it allowed the attainment of a glossy surface that accentuated the realism of the flesh colour.

Fig. 9 – Spectra obtained for the pink stratum of the sample presented in Fig. 8



a) EDS spectrum where we can detect Mercury (Hg), Lead (Pb) and Sulfur (S). b)  $\mu$ -FTIR spectrum.

Credits: Hercules Laboratory. Credits: Laboratório José de Figueiredo.

## Green estofado

- 28 In the case of the green tunic (Fig. 10), brochantite ( $\text{CuSO}_4 \cdot 3\text{Cu}(\text{OH})_2$ ) and antlerite ( $\text{Cu}_3(\text{SO}_4)_2(\text{OH})_4$ ) in a protein medium were identified (Fig. 11a) through  $\mu$ -FTIR analysis. The two copper sulphates with green colour were also identified by Raman spectroscopy (Fig. 11b). By SEM-EDS lead and tin, probably corresponding to lead-tin yellow, were detected.

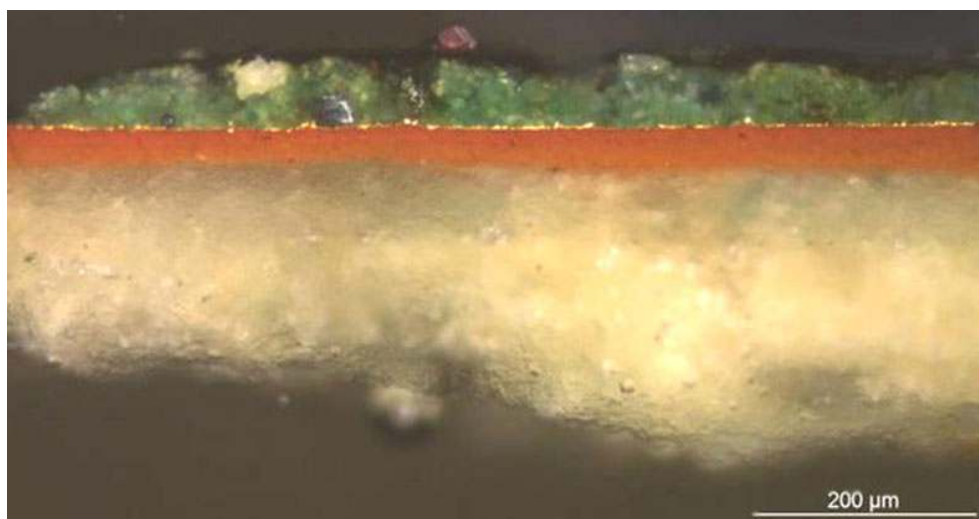
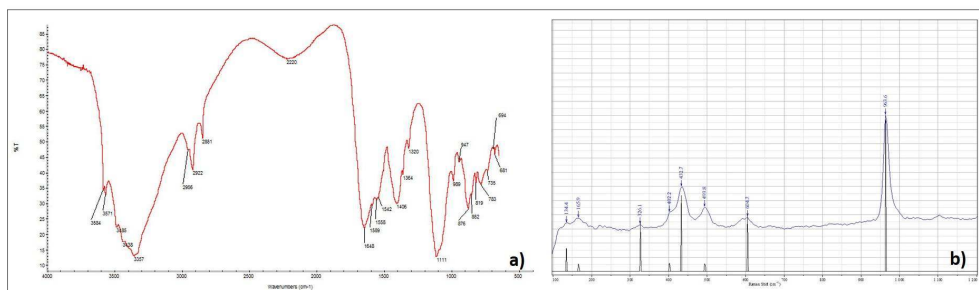


Fig. 10 Sample taken from the green area of the tunic

Optical microscopy: Cross section of the sample taken from the green area of the tunic. Again, we can see a typical cross section of *estofado* technique: a ground layer, followed by bole layer, the gold leaf and finally the green color layer.

Credits: Laboratório José de Figueiredo.

Fig. 11 Spectra obtained for the green stratum of the sample presented in Fig. 10



a)  $\mu$ -FTIR spectrum. With this result it was possible to identify that the green layer is constituted by brochantite, antlerite and a protein medium. b) Raman spectrum, which confirms the presence of brochantite and antlerite.

Credits: a) Laboratório José de Figueiredo. b) Hercules Laboratory.

- 29 Brochantite and antlerite are unusual pigments, and its use in Portugal was not reported in relation to ancient sculptures or paintings. Brochantite, natural or artificial, was identified in some works from Norway, German and Italy (Eastaugh et al 2004). Concerning to antlerite, it may have been used as pigment or may be a decay product of brochantite, formed by the action of microorganisms or air pollution associated with high humidity (Castro 2007). In the present case, however, antlerite should already be part of the paint when that was applied to the sculpture and should not be a product formed after painting. This is suggested by the fact that two other samples taken from the green colour in locations with different exposure to the environmental factors show the same composition. If antlerite had formed after painting, it would be expected that the change would be more significant in the place where the protective coating was not applied — which was not observed.

- 30 Regarding the mixture of lead-tin yellow with the green pigments, it is common practice in Portugal (Nunes 1615) and in other countries (Hommes 2002).
- 31 Contrary to what happens in the case of the red *estofado*, the incised marks were not observed. Although, the decoration also follows a pattern, which also suggest the existence of a pre-existing model.

## Brown and black colours

- 32 With respect to black pigments, in the original base a mixture of calcium carbonate and silicates bounded in an oil medium were identified. The  $\mu$ -FTIR spectra showed also some bands that could be attributed to a protein material. In the brown colour applied in hair area, iron, lead, silicon and aluminum were detected by SEM-EDS. Probably these elements result from the use of a mixture of ochre (composed iron compounds and clay materials) and white lead and are in accordance with the expected. By  $\mu$ -FTIR an oil medium was identified.

## Conclusion

- 33 As expected, the sculpture shows many characteristics common at the time, regarding to materials and techniques applied. For example, the stratigraphy observed in areas of *estofado* (mantle, tunic, sandals and base): ground layer, Armenian bole, gold leaf and polychrome layer applied with a tempera medium where pretty common. Also as expected, in the flesh areas a ground layer followed by a polychrome oil based layer was observed (Serck-Dewaide 2002). Moreover, in general, the pigments identified in the sculpture are in accordance with the materials used in the 17<sup>th</sup> century. Also the thematic of the motifs follows what was expected of a work of this time, allied to the treatment of its volumes.
- 34 However, two aspects are unusual.
- 35 The first is the employment of one part of the trunk that does not meet the good selection criteria for choosing the timber, which caused some conservation problems. This fact could possibly result from the fact that this sculpture could have been made by a less experienced craftsman or it just could mean that have been intended the use of available wood displayed at the time.
- 36 The second is the use of brochantite and antlerite, two uncommon green pigments that may be very useful to clarify issues related to the date and origin of the sculpture. Also, seems important to start to focus on the techniques for transfer the motifs, since other studies developed in Spain (Letona 2004) shows that sometimes the motifs cannot always be done freely (which happens in the case of the red mantle of Saint John). It is therefore probably that the same occurs in other sculptures in the national context. For that, however, further work is necessary.
- 37 This material and technical study also proved important for the development and implementation of an appropriate intervention methodology, allowing the selection of more suitable products to specific problems. For example, the use of materials compatible with the original ones, such as a protein adhesive to the fixation of lifted ground layer areas, or the fact that the wooden support own specific weaknesses regarding to the kind of wood chosen, makes us realize the highest importance to replace the filling material

presented in the sculpture clefts and fissures (which was a very rigid material that does not followed the natural wood movements) by a more suitable, compatible and easily reversible material, as the case of cellulose pulp. The applied methodology has also taken into account the fact that this sculpture is from a set, respecting of the criteria of reversibility and differentiation whenever possible. Also, the removal of some materials added after the execution of the work which are harmful were considered and performed, with the aim to stabilize chemical and physically the older materials of the sculpture.

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## RÉSUMÉS

Une sculpture en bois polychrome représentant Saint-Jean au Calvaire, probablement du 17<sup>ème</sup> siècle et de production portugaise, a fait l'objet d'une étude des matériaux et des techniques. Ont été utilisés la radiographie, la microscopie optique, la microscopie électronique à balayage, la spectroscopie infrarouge à transformée de Fourier et la spectroscopie Raman. Certaines caractéristiques inhabituelles ont été détectées, comme l'emploi de bois avec quelques imperfections et, surtout, l'utilisation de brochantite et antlérine comme pigments.

A polychrome wood sculpture depicting Saint John at Calvary, probably a 17<sup>th</sup> century Portuguese production, was the subject of a study that aimed to characterise its materials and techniques. Radiography, optical microscopy, scanning electron microscopy, Fourier transform infrared spectroscopy and Raman spectroscopy were used. Some unusual characteristics have been detected, like the employment of wood with some imperfections and, specially, the use of brochantite and antlerite as pigments.

## INDEX

**Mots-clés** : sculpture, sculpture polychrome, polychromie, bois, brochantite, antlérine

**Keywords** : sculpture, polychomy, polychrome sculpture, wood, brochantite, antlerite, Portugal

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